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ILLNESS DURING THE FIRST FIVE YEARS OF LIFE

RESULTS OF AN INQUIRY IN THE BOROUGH OF LUTON

BY

ROBERT M. DYKES, FRED GRUNDY, and E. LEWIS-FANING

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(1) Introduction

In a previous communication (Grundy, 1949), an interim report was made of the early results (for the period 0–2 years) of an inquiry into the sickness experience of a group of children during the first 5 years of life. The group comprised 1,849 babies* born in Luton during 1945 to women resident in Luton at the time. In the present paper three subjects in particular are examined:

(1) the volume of sickness and its broad pattern at different periods during the first 5 years of life;
(2) social class differences in sickness experience;
(3) hospital admissions.

For all three subjects the present report develops the account given for the first and second years of life in the interim report and continues the study to the end of the 5-year period.

For a number of reasons it has proved convenient to prepare the present account as a self-contained paper covering the entire survey period. In the first place, the social classification used in the interim report was the Registrar General's 1931 classification, whereas in the present report the 1951 classification has been adopted. Next, additional information which became available at the end of the survey period enabled a social class to be assigned to many parents who could not be classified when the interim report was prepared. Finally, much more detailed analyses have been made than was practicable at the time of the interim report—of special note, in the present report a study of social class differences is made for the main groups of diseases separately and for four social groups, namely the Registrar General's Groups 1 and 2 combined, R.G.3, R.G.4, and R.G.5. (In the interim report 1, 2, and 3 were combined to constitute one social group, and 4 and 5 to constitute a second.) Because of these procedural differences, the figures given here for the period 0–2 years are not directly comparable with figures for the corresponding years in the earlier contribution. The present paper therefore not only enlarges but in some respects supersedes the interim report.

In addition to the subjects just mentioned, the present paper contains a short appendix which illustrates the effect on social class differences when a modification of the Registrar General's classification is used. The appendix itself is not of great importance, but the reasons which led us to examine an alternative social class classification are not without interest.

Two years ago, the results were published of a national sample survey of mortality and morbidity during the first 2 years of life (Douglas, 1951). The national survey, employing a social class grouping based on the occupational groups of the Family Census, disclosed unmistakable gradients for morbidity; the Luton material at the stage of interim analysis did not. The national and local findings are not, however, necessarily in conflict: the presence of a national gradient does not exclude the existence of local areas with gradients steeper than the national, with gentler gradients, or with no gradient at all.

Douglas (1951), examining the Luton material critically, was unable to accept the absence of social class differences in Luton as fully substantiated. He thought that on the one hand the combinations of social classes examined in the interim report did not provide groups which were sufficiently contrasting, and that on the other hand the Family Census occupational groups classification might have shown social class differences in the Luton material which were masked by the Registrar General's classification. The extent to which the results of the interim analysis of the Luton data are modified by the more detailed analysis now made is clear from the text which follows; the appendix deals briefly with Douglas's second point.

In another communication, Dykes (1950) carried the Luton studies a step further. Depending on investigations collateral with the main study, he was led to conclude that in addition to the absence of social class differences there were also no differences

* 1,849 singlets. Seventeen pairs of twins (34 infants) were excluded because of the methodological complications their inclusion would have introduced.

in Luton when sickness incidence during the first year of life was analysed according to housing standards and standards of maternal care. Grundy (1950), pointing out that the presence of a social gradient for infant mortality cannot be assumed to imply a corresponding gradient for sickness, argued that extensive combined studies of infant sickness and infant mortality were needed to define the relation which the one bears to the other.

Whether differences in infant mortality rates at different social levels or in different administrative and geographical areas are due wholly, in part, or not at all, to differences in sickness rates is a question of considerable practical importance, but one which the present paper does not attempt to answer. Indeed, the facts needed to answer this question could only be obtained from morbidity and mortality studies conducted simultaneously in a number of areas according to a common plan.

The value of information to be gained from this type of investigation in areas "even where the infant mortality rate may not give rise to undue anxiety" is the subject of comment in a recent report of the Ministry of Health (1950); and we may perhaps be permitted to mention here that a study designed to clarify the mortality-morbidity issue in infancy is nearing completion* and will in due course become the subject of another communication.

(2) The Survey Population

The year 1945 proved, in one sense, to be an unfortunate choice for beginning the investigation. Luton had been a reception area during the early years of the war, and many women—often the young wives of men in the Services—had made the town their war-time home and were having their babies there. When the war was over these women began to return to London and other areas in a steady stream. The 1,883 babies originally included in the survey are compared below with the official returns (figures in brackets):

Sex	Male	Female	Total
Legitimate ..	901 (902)	839 (839)	1,740 (1,741)
Illegitimate ..	76 (77)	67 (67)	143 (144)
Totals ..	977 (979)	906 (906)	1,883 (1,885)

* Studies of sickness during their first year of life of infants born in 1952, and studies of infant deaths occurring in 1951, 1952, and 1953 are being conducted in fourteen areas according to a common plan, the total infant population under review being some 24,000. The local investigations, co-ordinated by the Department of Preventive Medicine of the Welsh National School of Medicine, are being undertaken in each area by the local Medical Officer of Health. The areas participating are: Ashton-under-Lyne, Blackburn, Cardiff, Gloucester County, Leyton, Luton, Preston, Rochdale, Slough, Soke of Peterborough, Walsall, Warwickshire County, Warrington, and West Ham.

The correspondence between the official return (Luton births published in the Registrar General's Annual Report for 1945) and the group of babies for whom cards were made out is virtually complete. But early losses were heavy.

The exclusion of 34 twins (mentioned earlier) reduced the number initially "exposed to risk" from 1,883 to 1,849. In 328 instances the Health Visitor found on making her first survey visit that the family had moved. These removals may be divided into two groups. Of the first (153 families) many had left the United Kingdom and the new addresses of a substantial proportion of the remainder could not be ascertained. These 153 might be regarded as outward transfers, or births which occurred in Luton to mothers normally resident elsewhere. The second group (175 families) differed from these "transfers out" only in that the father's civilian occupation was known and the child could therefore be assigned to a social class. In the "Exposed to Risk" Tables, these 328 infants are included but are allowed no exposure.

By the end of the 5-year follow-up period, another 199 infants had become lost to the Survey by a change of address. These, and losses by death (see Table I, cols 3 and 4, p. 34), are taken account of for the period during which their sickness history was available—*i.e.* up to the date of death or last contact made with the family by the health visitor, or in a few instances to a later date up to which records of hospitalization or notifications of infectious diseases were available.

(3) Method of the Survey

With the exceptions mentioned below, the enquiry was conducted by means of a questionnaire addressed to the child's mother. A record card was made out for each child, incorporating in the first place such facts as name and address, date of birth, sex, legitimacy, birth weight, maternal age and birth order, duration of marriage, and (for legitimate children) father's occupation. These particulars and certain others relating to housing standards were obtained from existing departmental records and verified when necessary on the occasion of a home visit.

As soon as practicable after the child's first birthday, and then after each succeeding anniversary of the birth until the survey was completed, a special visit was paid by a health visitor to the child's home. The child's mother was asked for information about the child's illnesses up to the date of the first visit, or thereafter during the interval which had elapsed since the previous visit. The nature, date of onset, and duration of the illness, as far as the mother could recall them, were entered on the record card by the health visitor.

Records of illnesses obtained in this way were checked against information from two other sources. Information

about infectious diseases occurring among the cohort (received by the department as an ordinary routine) was transferred to the record cards to amend or supplement information obtained by the health visitor. Also, during the entire survey period, hospital records of the four hospitals situated in the Borough (Luton Children's Hospital, Isolation Hospital, St. Mary's Hospital, Luton and Dunstable Hospital) were examined at intervals by a member of the Health Department staff; particulars relating to any child born during 1945 were abstracted, and appropriate additions or amendments were made on the survey record cards.

(4) Definitions and Indices of Sickness

Sickness.—This was defined for the purpose of the survey as an illness or an accident fulfilling one of the following requirements:

(*a*) it needed treatment in bed for 48 hours or more,
(*b*) a doctor was called,
(*c*) it left a recognized disability.

The adoption of this arbitrary definition implies that the amount of sickness recorded falls short of actuality. Many minor ailments, such as simple colds or the so-called teething troubles and bowel upsets of infancy, would in all likelihood be incompletely entered in the records. This consequence was foreseen and the definition of sickness was formulated in the above exclusive form on three grounds: first, because it seemed doubtful if trivial departures from health in infancy are sufficiently distinctive to be identified with any certainty; secondly, because many if not all would have been forgotten by most mothers (but perhaps remembered by some) after the elapse of weeks or months; thirdly, because it did not seem, in a survey which could not be expected to give more than a general picture of infant morbidity, that uncomplicated trivial incidents could usefully be included.

Groups of Illnesses.—The illnesses recorded were classified into ten broad groups, viz:

I. Pneumonia and bronchitis.
II. Influenza, colds, and other respiratory infections.
III. Gastro-enteritis, gastric influenza, diarrhoea, dysentery, and other diseases of the stomach.
IV. Infectious diseases, including measles, whooping cough, scarlet fever, mumps, and chicken pox.
V. Skin diseases, abscesses, and boils (other than of the ear).
VI. Accidents and injuries (including burns and scalds).
VII. Tonsillectomy and tonsillitis.
VIII. Diseases of the ear.
IX. Diseases of the eye.
X. Other diseases.

Examples of conditions recorded under Group X are: Swollen glands, jaundice, fluid on the knee, shingles, rectal prolapse, intussusception, and congenital malformations.

Social Class.—As mentioned earlier, social class was determined for the present paper by referring the father's occupation to the Registrar General's 1951 classification of occupation by social class. In 1945, when survey cards were originally made out, a large number of men were serving with the forces, predominantly in the army. According to the 1931 classification, these men, unless they held commissions, were allocated to social class 4 by the 1931 classification then employed. After the survey was completed an effort was made, in a large proportion of cases successfully, to discover the occupation of these men in civilian life. Most of them were in skilled occupations and the births were re-classified accordingly. We believe this was the right course to follow since the circumstances in which a child is reared are more likely to be determined by the father's civilian occupation than by his army rank at the time of the child's birth.

The relatively high proportion of Class 3 in our series (Luton, 1945—71 per cent., England and Wales, 1949—57 per cent.) is consonant with the results of a post-war local census, *Report on Luton* (1945), and also with what is known about the town's leading industries which all employ a high proportion of skilled labour.

Indices Studied.—Two indices of the volume of sickness experienced at each year of life (or in the case of the first year of life at each of the four periods, 0–3, 3–6, 6–9, and 9–12 months) are used:

(*i*) Incidence rate—the ratio of the number of sickness incidents occurring in a group of children during the year* before attaining a specified age, to the average number under observation during the period in question:
i.e. (No. of sicknesses recorded) ÷ (Average number exposed to risk of sickness).

(*ii*) The average number of days of sickness per child—the ratio of the total days of sickness during the year* before attaining any age, to the average number alive during the year:
i.e. (Total days of sickness) ÷ (Average number exposed to risk of sickness).

The first index, whilst having the advantage of enabling hospital admission rates to be stated, has, on the other hand, the disadvantage of recording every illness as the equivalent of every other in "aggregated" sickness rates; it fails, moreover, to

* Or 3 months, in the first year of life.

provide an adequate measure of the volume of sickness from different causes at different ages. For these reasons alone the second index would be the one of preference, but, in addition, since birthday anniversaries are arbitrary boundaries and illnesses beginning in one year often extend into the next, the second index avoids the necessity of allocating an incident entirely to the period in which it commences.

In apportioning illnesses whose date of onset or duration were vaguely stated, an element of arbitrariness had to be introduced, but any error incurred by this procedure is more than offset by the advantage of the index made available.

The duration of an illness, never easy to define, is particularly difficult to delimit in infancy. Apart from errors due to faulty parental memory—inevitable in inquiries of this kind—the duration attributed to such conditions as whooping cough and bronchitis, for example, must depend to no small extent on personal standards of judgment. Mainly because we recognize such limitations as these, incidence rates as well as rates based on days of sickness are quoted in some parts of the paper.

The numerators of the indices need no comment; the method of calculating the denominator common to both—*i.e.* the number exposed to risk of sickness in each year (or part of a year) of life—requires a word of explanation.

In most investigations it can be assumed that withdrawals are evenly distributed in the final period of observation, so that on an average each is exposed for half the period. In the present investigation this assumption cannot be made. Health visitors did not make their visits exactly at anniversaries of births, but usually some weeks (0–13) thereafter. The ages at which infants were lost sight of are therefore evenly distributed, not throughout each year of age but throughout the range x to $(x+0\cdot25)$. Because of this it was necessary to calculate, for each child lost sight of, the exact length of exposure from birth to the date when the last contact was made and sickness history recorded. A similar argument applies to children lost to the inquiry by dying before attaining their fifth birthday.

In Table I, which shows deaths and withdrawals at each period of life, the items entered under df_x and wf_x are the sums of the fractions of the period contributed respectively to their final period of exposure by those who died or withdrew.

(5) Total Volume of Sickness

In Table II, the number of morbid incidents of all kinds per hundred children is shown for each period of life.

TABLE I

DEATHS AND WITHDRAWALS AT EACH PERIOD OF LIFE

x	Period of Life	Deaths		Withdrawals		Existing at Close of Observation s_x	Number Exposed to Risk E_x
		d_x	df_x	w_x	wf_x		
0·25	0– mths	35	3·5	328*	0	—	1,490
0·50	3– mths	7	1·7	—	—	—	1,481
0·75	6– mths	—	—	—	—	—	1,479
1·00	9– mths	1	—	1	1·0	—	1,478
2	1– yrs	4	1·0	70	17·9	—	1,422
3	2– yrs	2	0·7	44	5·3	—	1,363
4	3– yrs	2	1·1	49	9·5	—	1,317
5	4– yrs	4	1·8	35	3·4	—	1,272
		55		527		1,267	1,849

* Including 153 "transfers out"—see para. 3 of Section 2 (p. 32).

Column 6 shows the number exposed to risk of sickness at each period of life. The formula employed for calculating this number is explained below; the question of bias introduced by withdrawals is discussed in Section 8 (p. 39).

The number of children exposed to risk of sickness during any year of life (see note) for the whole of that year is clearly equal to the total births less the sum of the withdrawals (w) and deaths (d) occurring in the year (s) up to attaining age x. The deduction made for these withdrawals and deaths is represented by Term 1 in the formula:

$$E_x = \text{total births} - \underset{0}{\overset{x}{\Sigma}} (d_x + w_x) + df_x + wf_x$$
$$\qquad\qquad\qquad\qquad\qquad\qquad\quad (1) \qquad (2) \quad (3)$$

The expression df_x (Term 2) is then added, being the sum of the increments of the year of dying during which the d_x children remained in the survey before death; similarly, the addition of the term wf_x makes a corresponding adjustment for the withdrawals, being the sum of the fractions of the year of withdrawal for which they were exposed to risk before they were lost sight of. Thus, to take a numerical example, E_2 (at 1–2 years) in Table I becomes:

$$E_2 = 1{,}849 - (47 + 399) + 1 + 18$$
$$= 1{,}849 - 446 + 19$$
$$= 1{,}422.$$

NOTE: "year" should be read as "year or period", whenever it occurs in this footnote.

TABLE II

ATTACK RATES PER 100 CHILDREN EXPOSED, AT DIFFERENT PERIODS OF LIFE

Period of Life	Number of Illness Incidents	Rate per 100 Children Exposed
0– mths	103	6·9
3– mths	129	8·7
6– mths	139	9·4
9– mths	175	11·8
Total 1st yr	546	36·9
2nd yr	650	45·7
3rd yr	513	37·6
4th yr	671	51·0
5th yr	510	40·1

In Table III (opposite) the morbid incidents are classified according to cause.

The general picture presented by the Tables is readily perceived. Respiratory infections (Groups I and II) are the leading causes of sickness during the first year of life, when they account for half the recorded incidents.

Thus, fifteen children in every hundred had an attack of pneumonia or bronchitis beginning in the first year of life, or to be precise, the attack rate from

TABLE III

INCIDENTS CLASSIFIED ACCORDING TO CAUSE (GROUPS I–X, see p. 33) AT DIFFERENT PERIODS OF LIFE

Period of Life	Illness Groups									
	I	II	III	IV	V	VI	VII	VIII	IX	X
0– mths	36 (2·4)	9 (0·6)	10 (0·7)	14 (0·9)	5 (0·3)	2 (0·1)	— —	4 (0·3)	3 (0·2)	20 (1·3)
3– mths	51 (3·4)	10 (0·7)	18 (1·2)	19 (1·3)	11 (0·7)	2 (0·1)	— —	3 (0·2)	2 (0·1)	13 (0·9)
6– mths	63 (4·3)	18 (1·2)	15 (1·0)	25 (1·7)	1 (0·1)	— —	— —	5 (0·3)	— —	12 (0·8)
9– mths	72 (4·9)	9 (0·6)	26 (1·8)	42 (2·8)	3 (0·2)	2 (0·1)	— —	7 (0·5)	— —	14 (0·9)
Total										
1st yr	222 (15·0)	46 (3·1)	69 (4·7)	100 (6·7)	20 (1·3)	6 (0·4)	— —	19 (1·3)	5 (0·3)	59 (4·0)
2nd yr	135 (9·5)	37 (2·6)	43 (3·0)	325 (22·9)	18 (1·3)	17 (1·2)	10 (0·7)	16 (1·1)	3 (0·2)	46 (3·2)
3rd yr	60 (4·4)	29 (2·1)	15 (1·1)	284 (20·9)	11 (0·8)	20 (1·5)	33 (2·4)	17 (1·2)	1 (0·1)	43 (3·1)
4th yr	77 (5·9)	31 (2·3)	16 (1·2)	413 (31·4)	11 (0·8)	18 (1·4)	47 (3·6)	18 (1·4)	1 (0·1)	39 (3·0)
5th yr	37 (2·9)	36 (2·8)	8 (0·6)	278 (21·9)	5 (0·4)	17 (1·3)	73 (5·7)	20 (1·6)	3 (0·2)	33 (2·6)

NOTE: Figures in brackets are rates per 100 child-years of exposure.

these causes during the first year of life was 15 per 100 children.

During the second year of life this group of infections is much less prominent, and in succeeding years makes a diminishing contribution to the total number of illnesses recorded.

From the first birthday onwards the situation is dominated unmistakably by the notifiable infectious diseases (Group IV), when in each year they account for over half the recorded sickness.

The location of the bulk of respiratory infections in Group I (pneumonia and bronchitis) is almost certainly due to the understatement of minor illnesses—probably a gross understatement—for reasons previously stated. It will be seen that at 0–1 year this group of illnesses containing most of the serious respiratory infections, outstrips in numerical importance every other group by a wide margin.

The high attack rates in the 2nd and 4th year of life (Table II) are mainly attributable to a high incidence of measles in the late months of 1946 and the early months of 1947, and a similar epidemicity 2 years later.

In Tables IV and V sickness rates are expressed in days of sickness per child exposed at different periods.

Table IV shows that the average number of days of sickness in the first year of life was 7·3 per child, distributed approximately as 1·3 days in the first 3 months of life and 2 days in each of the remaining 3-month periods. In the next 4 years of life the rate lies between 6 and 8 days' illness per child per year. Comparing Table IV with Table II, their likeness is evident. In both, for example, the fourth year shows the highest, and the second year the next highest rate. Comparing Table V with Table III, the similarity of trends disclosed by the alternative indices is seen to extend to individual categories of

TABLE IV

DAYS OF ILLNESS PER CHILD EXPOSED TO RISK, ALL CAUSES COMBINED

Period of Life	Days of Illness	Rate per Child Exposed
0– mths	1,893	1·27
3– mths	2,821	1·90
6– mths	3,126	2·11
9– mths	2,949	2·00
Total 1st yr	10,834*	7·31
2nd yr	11,638	8·19
3rd yr	8,727	6·40
4th yr	11,045	8·39
5th yr	7,647	6·01

* The difference between this figure and the summation of the four quarters of the 1st year is explained in para. 3 under the heading "indices studied" (p. 33).

TABLE V

DAYS OF ILLNESS FROM DIFFERENT CAUSES PER CHILD EXPOSED TO RISK

Period of Life	Illness Groups									
	I	II	III	IV	V	VI	VII	VIII	IX	X
0– mths	0·35	0·09	0·09	0·14	0·12	0·04	—	0·01	0·07	0·29
3– mths	0·69	0·06	0·11	0·38	0·27	0·02	—	0·07	0·09	0·16
6– mths	0·91	0·12	0·07	0·40	0·27	0·01	—	0·12	0·08	0·06
9– mths	0·67	0·04	0·20	0·54	0·09	0·06	—	0·12	0·01	0·12
Total										
1st yr	2·62	0·31	0·47	1·47	0·76	0·13	—	0·32	0·24	0·63
2nd yr	1·31	0·32	0·41	4·26	0·38	0·39	0·04	0·19	0·02	0·63
3rd yr	0·78	0·25	0·10	3·87	0·13	0·39	0·19	0·15	0·01	0·49
4th yr	0·78	0·24	0·11	5·89	0·10	0·27	0·30	0·20	—	0·35
5th yr	0·35	0·19	0·03	3·92	0·04	0·24	0·49	0·15	0·03	0·31

TABLE VI

SICKNESS RATES AT DIFFERENT AGE PERIODS IN DAYS PER CHILD EXPOSED TO RISK IN EACH OF THE SOCIAL CLASSES

Period of Life	Social Class				All Classes (excluding illegitimate)
	1 and 2	3	4	5	
0– mths	0·85* (66)	1·37* (107)	0·80* (62)	2·20* (172)	1·28 (100)
3– mths	3·11* (158)	2·00 (102)	1·41* (72)	1·00* (51)	1·97 (100)
6– mths	1·59* (76)	2·31* (110)	1·38* (66)	2·00 (95)	2·10 (100)
9– mths	0·79* (39)	2·13* (105)	1·85 (91)	3·22* (159)	2·02 (100)
Total 1st yr	6·16* (83)	7·87* (106)	5·47* (73)	8·40* (113)	7·40 (100)
2nd yr	8·19 (98)	8·63* (103)	7·45* (89)	6·99* (84)	8·35 (100)
3rd yr	6·92 (104)	6·68* (101)	6·43 (97)	5·96 (90)	6·63 (100)
4th yr	7·08* (85)	8·53 (102)	8·55 (102)	7·52 (90)	8·35 (100)
5th yr	7·36* (124)	6·05 (102)	4·84* (82)	4·92* (83)	5·94 (100)

The figures in brackets show individual rates as a percentage of the rate for "All Social Classes", taking Rate = 100.
* Indicates statistically significant differences from the rate of the same period for all classes combined:

$$i.e.\ \frac{\text{(Actual—Expected) days of sickness (based on all classes)}}{\sqrt{\text{Expected days of sickness}}} > 2{\cdot}5$$

sickness. Both indices show the pre-eminence of bronchitis and pneumonia in the first year of life, and their supersession from the second year onwards by the specific fevers of childhood.

(6) Social Class and Sickness

In this section it is not proposed to duplicate the tabulations by presenting data based on both the indices used in the preceding section. The analyses we have made show that it makes no substantial difference to the results whether "days of sickness" or "incidents" is taken as index. In the Tables which follow only the former, which we have described as the index of preference, is used.

The social gradient for all causes can be studied from the actual rates presented in Table VI, but is more easily appreciated from rates expressed as percentages of the rate for all classes combined (figures in parenthesis in Table). The number of children at risk at each age period in the several social groups is given in Table VI*A*.

TABLE VI*A*

NUMBER OF CHILD YEARS OF EXPOSURE ON WHICH EACH SICKNESS RATE IS BASED (ILLEGITIMATE NOT INCLUDED)

Period	Social Class				All Classes
	1 and 2	3	4	5	
0– mths	140	1,012	190	70	1,412
3– mths	140	1,006	189	70	1,405
6– mths	140	1,006	188	70	1,404
9– mths	140	1,006	188	69	1,403
Total 1st yr ..	140	1,007	189	70	1,406
2nd yr ..	130	971	182	67	1,350
3rd yr ..	121	935	173	63	1,293
4th yr ..	114	902	171	63	1,250
5th yr ..	108	872	166	62	1,209

Rates for illegitimate infants are not made the subject of comment, and their sickness experience has been omitted from the Table.

The general picture presented in Table VI is one of absence of any consistent social gradient. For the first year of life there is an upward gradient to the extent that the rate for children of unskilled workers is higher than that for the children of well-to-do classes. But Social Class 4 have the lowest rate of all. The 5th year shows a downward gradient and there is a similar trend in the 3rd year. In the 2nd and 4th years the rates are almost the same in each of the social groups.

As, however, these rates are for all causes of sickness combined, a nil gradient in the Table could conceal substantial gradients for individual categories of sickness, some of which might be upward and others downward. Moreover, the existence of a gradient in the Table could be due to the summation of several gradients for individual diseases, or alternatively could be ascribable in its entirety to a single category gradient.

Table VII shows the rates for bronchitis and pneumonia (Group I) and Table VIII the rates for the infectious diseases (Group IV). Table VII discloses an upward gradient for the 1st year of life and for each quarter of the 1st year; in the 3rd year there is a contrary gradient, and in the 2nd, 4th, and 5th years, no gradient at all. In Table VIII (opposite) no consistent gradient is apparent.

TABLE VII

SICKNESS RATES DUE TO PNEUMONIA AND BRONCHITIS, IN DAYS PER ANNUM PER CHILD EXPOSED TO RISK, BY SOCIAL CLASS

Period of Life	Social Class				Total Classes 1–5
	1 and 2	3	4	5	
0– mths	0·05	0·28	0·59	1·20	0·35
3– mths	0·75	0·64	1·12	0·90	0·73
6– mths	0·33	1·01	0·42	0·70	0·85
9– mths	—	0·72	0·93	0·51	0·67
Total 1st yr	1·13	2·65	3·06	3·31	2·58
2nd yr	1·31	1·26	1·81	1·19	1·34
3rd yr	1·04	0·85	0·79	0·22	0·83
4th yr	0·79	0·88	0·73	0·38	0·83
5th yr	0·58	0·36	0·25	0·50	0·37

TABLE VIII

SICKNESS RATES DUE TO INFECTIOUS DISEASES, IN DAYS PER ANNUM PER CHILD EXPOSED TO RISK, BY SOCIAL CLASS

Period of Life	Social Class				Total Classes 1–5
	1 and 2	3	4	5	
0– mths	—	0·19	0·05	0·20	0·15
3– mths	1·01	0·39	0·18	—	0·41
6– mths	0·15	0·52	0·02	0·60	0·42
9– mths	0·24	0·64	0·34	0·61	0·54
Total 1st yr	1·41	1·73	0·59	1·40	1·53
2nd yr	4·64	4·62	3·39	2·57	4·35
3rd yr	4·12	3·97	3·65	4·35	3·96
4th yr	4·39	5·82	7·15	5·38	5·85
5th yr	4·56	3·88	3·17	3·99	3·85

We make no extended reference to other groups of causes, for the numbers of incidents attributed to them are too small to justify the inclusion of Tables. We mention only in passing that our analyses showed skin diseases to have lower rates in Social Classes 4 and 5; tonsillectomy and tonsillitis a higher rate among well-to-do children; some excess of gastro-enteritis, diarrhoea, and dysentery in Class 5 in the first year of life—but confined entirely to the first 3 months; and an upward gradient for diseases of the ear during each of the first 3 years of life. On this last point a brief comment is made.

The ninety incidents in Group VIII (diseases of the ear) account for only about 3 per cent of all the recorded sickness incidents (2,890) during the 5-year period, and it would be unwise to draw conclusions from these numbers standing alone. The clinical association of diseases of the ear and respiratory infections gives, however, some ground for regarding as other than fortuitous the upward gradient of ear diseases during the first year of life, when it is steepest. And it is not unreasonable to regard the upward gradient for diseases of the ear in the second and third year of life as a likely consequence of the upward gradient for respiratory infections at 0–1 year.

These rather speculative inferences are not however of great importance here. The outstanding facts established by the social class analysis is the presence of an upward gradient for bronchitis and pneumonia and a similar gradient for all causes during the first year of life.

A question these facts raise is whether the one accounts entirely for the other; and in Table IX we therefore examine the effect of excluding bronchitis and pneumonia from the sickness rates for all causes.

Taking the first year as a whole, the differences between Classes 1 and 2 and Class 5 are virtually extinguished by this exclusion, from which it might

TABLE IX

SICKNESS RATES IN DAYS PER CHILD EXPOSED TO RISK FOR ALL CAUSES (EXCLUDING PNEUMONIA AND BRONCHITIS)

Period of Life	Social Class				Total
	1 and 2	3	4	5	
0– mths	0·80	1·09	0·21	1·00	0·94
3– mths	2·36	1·36	0·29	0·10	1·24
6– mths	1·26	1·30	0·96	1·30	1·26
9– mths	0·79	1·41	0·92	2·71	1·35
Total 1st yr	5·03	5·22	2·41	5·09	4·82

appear that our question is answered in the affirmative.

But the wide differences remaining at 3–6 and 9–12 months suggest that no such simple interpretation of the facts is admissible. It is apparent that an extended analysis based on bigger numbers than we have from the Luton survey is needed to unravel the complexities of the situation.

(7) HOSPITAL ADMISSIONS

Illnesses for which children were admitted to hospital are included but not distinguished in the Tables in previous sections. As presented below (Table X) they were obtained directly from a scrutiny of hospital records.

TABLE X

HOSPITALIZATION OF LUTON CHILDREN BORN IN 1945

Reason for Admission	Age (yrs)					Total
	0–	1–	2–	3–	4–	
Pneumonia and bronchitis	9	5	5	2	1	22
Influenza, colds, and other respiratory infections	—	—	1	—	1	2
Infectious diseases	2	1	5	8	9	25
Gastro-enteritis, dysentery, etc.	11	3	1	1	—	16
Skin diseases (excluding pemphigus)	2	3	3	1	4	13
Accidents and injuries	3	7	2	7	11	30
Tonsillectomy, tonsillitis	—	—	17	27	62	106
Diseases of the ear	—	2	1	2	5	10
Malformations	10	6	—	—	2	18
Hernia	3	2	2	1	8	16
Feeding difficulties, malnutrition	13	—	—	—	—	13
Pemphigus	7	—	—	—	—	7
Others (specified)	5	2	9	6	10	32
Others (not specified)	3	2	5	4	8	22
Total	68	33	51	59	121	332
Number Exposed to Risk	1,482	1,422	1,363	1,317	1,272	
Rate per 100	4·6	2·3	3·7	4·5	9·5	
Days in Hospital	1,774	328	568	655	988	
Average Duration of Stay in Hospital	25·5	10·0	10·7 (14·3)	10·7 (17·5)	7·9 (12·9)	

NOTE: Admissions for circumcision are not included. Figures in brackets are durations excluding tonsillectomies.

If circumcisions are disregarded, the number of admissions to hospital in the first year of life is 68, in the 2nd 33, in the 3rd 51, in the 4th 59, and in the 5th 121. These numbers related to the numbers exposed to risk in each year of life yield hospital admission rates for the successive years of life of 4·6, 2·3, 3·7, 4·5, and 9·5 per 100 exposed to risk. The high rate in the 5th year is clearly due to tonsillectomies.

Admissions of the same child on more than one occasion are not distinguished.

The average duration of in-patient stay for successive years of life was 25·5, 10·0, 10·7, 10·7, and 7·9 days; becoming, when tonsillectomies are disregarded, 14·3, 17·5, and 12·9 days for the 3rd, 4th, and 5th years respectively.

The mild form assumed by the common infectious diseases in childhood is reflected in low ratios of admissions to notified cases. Thus, for example, the admission rate (Infectious Diseases Hospital, Luton) for measles per 100 notified cases was 0·56 in 1950, and 0·90 in 1951. The corresponding rates for whooping cough and scarlet fever were:

Whooping cough 4·45 (1950), 4·06 (1951);
Scarlet fever 22·15 (1950), 12·72 (1951).

During this 2-year period, notifications of measles outnumbered whooping cough by 3 to 1 and scarlet fever by 5 to 1. Relating hospital admissions to incidents recorded in the survey, we have an admission rate for the 5-year period of 2 per cent. (25/1,400) for infectious diseases, which compares with 4 per cent. (22/531) for pneumonia.

The total number of hospital admissions is too small for the rates for individual causes to have much meaning. They are given for grouped causes in Table XI, where proportionate rates for Luton are displayed alongside corresponding rates for England and Wales quoted from a preliminary study of in-patient discharges during the first half of 1949 (McKay, 1951).

Comparability of proportionate rates in the two series is to some extent destroyed by the differing proportions classified under "Other Causes" in the national and local series. This applies both to the first year of life and to the period 1–4 years. For the period 1–4 years the much higher proportion of admissions for Tonsillectomy in the Luton series is also a distorting influence, but fortunately in a contrary direction. Taking "Other Causes" and Tonsillectomy together, their contribution to the total rate is 49 per cent. in the national series, and 55 per cent. in the Luton series.

TABLE XI

LEADING CAUSES OF ADMISSION TO HOSPITAL

Rate per annum per 100 children, Luton, and percentage distribution, England and Wales and Luton compared (Males and females combined)

Age (yrs)	Leading Causes of Admission	Percentage Distribution		Rate per annum per 100 Children
		England and Wales	Luton	Luton
0–1 (Total at risk 1,482)	Congenital malformations	15·7	14·7	0·7
	Gastro-enteritis and colitis	10·6	16·2	0·7
	Pneumonia and bronchitis	13·1	13·2	0·6
	Nutritional maladjustments	6·4	19·1	0·9
	All other specified causes	27·6	32·4	1·5
	All other unspecified causes	26·7	4·4	0·2
	All Discharges (other than special admissions)	100·1	100·0	4·6
1–4 (Total at risk 5,374)	Congenital malformations and hernia	13·8	7·6	0·4
	Bronchitis, pneumonia, and upper respiratory tract infections, acute pharyngitis, and tonsillitis	9·7	6·8	0·3
	Otitis media and mastoiditis	6·9	3·8	0·2
	Measles, scarlet fever, and whooping cough	6·6	7·6	0·4
	Tuberculosis	2·7	0·8	0·04
	Infections of skin and subcutaneous tissue	3·0	4·5	0·2
	Gastro-enteritis and colitis	0·7	1·9	0·1
	Burns, scalds, wounds, superficial injury, head injury	5·7	10·2	0·5
	Appendicitis	1·6	1·5	0·1
	Hypertrophy of tonsils and adenoids	17·1	39·0	1·9
	Other causes	32·1	16·3	0·8
		49·2	55·3	2·7
	All Discharges (other than special admissions)	99·9	100·0	4·9

NOTE: (Table 1–4 years)
(1) Rates in Column 5 are (Number of discharges in 4 years) ÷ (Number of years of life exposed in 4 years).
(2) In the Registrar General's publication, the sexes are given separately and in some instances two or more causes listed separately by the Registrar General are combined in our Table.

In both series a substantial proportion of specified causes at 0–1 year are assigned to four headings:

Congenital malformations,
Gastro-enteritis and colitis,
Pneumonia and bronchitis,
Nutritional maladjustments.

These causes account for 46 per cent. of all admissions in the national series and for 63 per cent. in the Luton series.

In the period 1–4 years, the bulk of admissions are not credited to a few causes as they are at 0–1 year. The numerical importance of a variety of surgical conditions as causes of admission to hospital after the first year of life is apparent. In both the national and the local series, congenital malformations, hernia, burns, and physical injury account for

about 40 per cent. of admissions for specified causes other than hypertrophy of the tonsils and adenoids. The relatively important place occupied by *non*-specific infections of the respiratory tract and ear compared with the common specific fevers of childhood is noteworthy. And the large number of admissions for tonsillectomy at these early ages will not escape attention.

(8) Discussion

The dependability of our data and inferences can be impugned on many different grounds. Incompleteness of histories obtained by health visitors, inaccuracies in the stated durations of recorded illness, and the big losses by removals, particularly during the first year of life, are potential sources of error which require discussing.

There is no means of estimating directly how far health visitors succeeded in obtaining complete records of sickness as defined; and no means whatever of knowing whether there were greater deficiencies in the records of one social class than another because of differing degrees of co-operation or ability to remember illnesses which had occurred some time previously. There is, however, some information relevant to the first issue.

Records of infectious diseases and of admission to hospital obtained independently of the main survey suggest that the health visitors' histories were reasonably complete. In only a very few instances had they failed to record an infectious disease or a hospital admission which came to notice by some other means. Also (as Table XII shows) the health visitors' records gave incidence rates for the infectious diseases considerably in excess of notification rates, and in close agreement with a recent estimate for London (Benjamin and Gore, 1952).

Table XII

INCIDENCE OF COMMON INFECTIONS OF CHILDHOOD
(Percentage of children attacked by the age of 5 years)
Estimate for London and recorded incidence for Luton compared

Disease	London County Council	Luton
Chicken Pox	20	14
Rubella	7	46
Measles	35 } 42	
Mumps	10	10
Whooping Cough	25	32
Scarlet Fever	4–5	2
Total	102	104

Against this it is not easy to accept at face value the total days of recorded illness shown in Table XIII.

Table XIII

DISTRIBUTION OF CHILDREN IN ALL SOCIAL CLASSES BORN IN LUTON IN 1945 ACCORDING TO THE NUMBER OF DAYS OF ILLNESS EXPERIENCED DURING THE FIRST 5 YEARS OF LIFE*

Number of days of Sickness	Number of Children	Number of days of Sickness	Number of Children	Number of days of Sickness	Number of Children
0	193	19	5	116–122	8
1	—	20	2	123–129	3
2	1	21	78	130–136	5
3	1	22	2	137–143	3
4	6	23	—	144–150	4
5	6	24	16	151–157	4
6	1	25–31	106	158–164	—
7	33	32–38	74	165–195	6
8	2	39–45	99	196–227	1
9	2	46–52	56	228–258	1
10	12	53–59	78	259–288	1
11	—	60–66	35	289–319	—
12	1	67–73	36	320–349	—
13	—	74–80	22	350–379	1
14	117	81–87	24		
15	4	88–94	18	Total	1,125
16	5	95–101	19	Not Stated	142
17	12	102–108	10		
18	4	109–115	8	Total	1,267

* Only children who completed the five years are included.

In the first place it is hard to believe that 193 children reached their fifth birthday without once needing treatment in bed for 48 hours or requiring the services of a doctor. This could be true without being inconsistent with the facts of Table XII (*i.e.* 104 incidents per 100 children by the age of 5 years), for a high proportion of the children who had at least one notifiable infectious disease were shown by our records to have had more than one. But the figure of 193 without recorded illness must raise a doubt about the completeness of the records.

The incidence of accidents recorded by the survey also appears to be grossly understated. Rowntree (1950), in a 2-year follow-up of the children included in the Maternity Survey of Great Britain, gives figures from which it appears that the incidence of treated accidents in the first 2 years of life is 80 per 1,000. The comparable rate in the Luton data is 16 per 1,000. If this order of disparity was at all likely to apply to infant sickness in general our records would be worthless, but there is no reason to believe that this is so. In the Luton survey the enquiries of the health visitor were probably mainly focused on disease, and, in consequence, the less serious accidents and injuries were not recorded. The high proportion of recorded accidents and injuries which were admitted to hospital over the 5-year period (40 per cent.) tends to confirm this view.

A scrutiny of individual records showed that the stated duration of different illnesses was as a rule consistent with expectations on clinical grounds, though, as Table XIII indicates, there was a tendency

to round off the length of an illness to the nearest week. The margin of inaccuracy from this cause would doubtless be narrowed in an enquiry with more frequent visits, though not, for reasons suggested earlier, entirely eliminated. A certain degree of approximation is inevitable in any questionnaire enquiry based on recollections, and this fact is recognized.

Turning next to uncertainties introduced by withdrawals from the survey, the question arises whether the social class gradients displayed would have been different had the children lost sight of remained in the survey. There are two separate problems; first, whether the social classes were represented in the same proportions among withdrawals as they were in the group of 1,521 children whose social class is known; secondly, whether the sickness experience of the withdrawals taken class by class was in any way unusual.

The first question is answered in Table XIV, from which it appears that there was an excess of withdrawals in Social Classes 1 and 2.

TABLE XIV
WITHDRAWALS

Social Class ..	1 and 2	3	4	5	Illegitimate	All Groups
Total ..	145	1,033	190	70	83	1,521
Withdrawals	31	129	20	7	11	199
Per cent. Withdrawals	21	13	11	10	13	13

NOTE: The 328 children who were lost to the survey before the health visitor's first enquiry are ignored.

A detailed analysis of the 328 "transfers out" and withdrawals in the first year of life showed, moreover, an overweighting with infants born to mothers younger on the average than survey mothers generally (43 per cent of the 328 mothers who withdrew were under the age of 25, compared with 21 per cent. of the remaining mothers). The duration of marriage of the withdrawals was overweighted with durations of less than one year, and a high proportion of removals were first-born children compared with other births (60 per cent. of the "transfers out" and 45 per cent. of the first-year removals, compared with 34 per cent. of other births). If therefore, the original cohort is regarded as "representative" in some sense, then the survey survivors after one year appear as an unrepresentative group. In fact, the group remaining in the survey at the end of the first year cannot be said to be representative of anything but itself, though it probably reflects more truly than the original cohort the stable population of Luton at the time.

The second and more important issue (whether the health of withdrawals taken class by class was representative of the survey population as a whole) is a question which unfortunately cannot be satisfactorily resolved. For withdrawals after the first year of life, it is true, we can compare the sickness experience before withdrawal of each social class with the contemporaneous experience of corresponding groups remaining in the survey for periods longer than one year. Then, assuming that the relation between the sickness experience of withdrawals and non-withdrawals would have continued unchanged had the withdrawals remained in the survey, an estimate can be made of the effect their extended inclusion would have had on sickness rates. On the basis of this assumption, which is one of rather dubious applicability, we satisfied ourselves that losses after the first year of life would not have altered the Tables in any material particular had they been included. But it was, of course, during the first year of life that withdrawals were heavy enough to be likely to introduce a serious bias; and it is for just this period that no arithmetical device is of any avail whatever.

Enough has been said to indicate that imperfections of the survey method and deficiencies in the records set bounds to the conclusions which can be drawn with confidence from the data at our disposal.

We believe, nevertheless, that if the survey is looked upon largely as a pilot enquiry it is not without substantial value. Inasmuch as it sketches an outline of the pattern of morbidity in infancy and brings into relief inadequacies of method, it can serve as a useful guide to the conduct of more extensive researches in this little-explored field.

The close correspondence between the sickness rates, stated alternatively in terms of incidents and days of sickness, and the independent checks afforded by hospital records and notifications of infectious diseases encourages us to believe, moreover, that the survey presents a reasonably true picture of the more serious illnesses suffered by a child population during the first 5 years of life. Though, of course, the extent to which it represents the experience of the child population of the country as a whole, or of child populations elsewhere in the country, must be entirely conjectural.

But if the sickness rates for the infant survey population as a whole have a title to a fair degree of confidence, far greater caution is needed in drawing inferences when differences between social groups are examined. Even for the population to which the survey relates, it is not possible to answer with any finality questions about the influence of social class

on sickness rates in infancy and early adolescence. To conclude, as we do, in the summary which follows, that with the exception of respiratory infections in the first year of life no consistent social gradient was demonstrated is in a sense non-commital. It is not to say that none exists.

(9) Summary

A questionnaire enquiry into the sickness experience during the first year of life of 1,849 children born in Luton during 1945 is described.

The effect of withdrawals (heavy during the first year) and certain imperfections of the records are examined critically.

The report portrays the broad pattern assumed by sickness at different periods during the first 5 years of life, its social class distribution, and the demand on hospital in-patient care.

Incidence rates and days of sickness per child are used as alternative indices of the volume of sickness.

The following conclusions are proposed:

(1) The leading causes of sickness during the first year of life are pneumonia and bronchitis, which account for half the recorded incidents in that period.

(2) From the first birthday onwards the notifiable infectious diseases account each year for half the recorded incidents.

(3) The average number of days of sickness per child was 7·3 in the first year of life, and from 6 to 8 days per year at the ages of 1 to 4 years.

(4) No social gradient progressing without interruption in either upward or downward direction was shown at any period of life for all causes combined.

(5) The respiratory infections show an upward gradient for the first year of life, and for each quarter of the first year.

(6) The notifiable infectious diseases show no consistent gradient at any period.

(7) Hospital admission rates for the successive years of life (disregarding circumcisions) are 4·6, 2·3, 3·7, 4·5, and 9·5 per 100 children exposed to risk. The high rate in the fifth year is due to tonsillectomies.

(8) At 0–1 year, 63 per cent. of admissions to hopital may be placed under one of four headings:

Congenital malformations,
Gastro-enteritis and colitis,
Pneumonia and bronchitis,
Nutritional maladjustments.

In the period 1 to 4 years there is no similar concentration of causes of hospital admissions; during this period the numerical importance of a variety of surgical conditions is noteworthy.

We wish to acknowledge our indebtedness to the many health visitors and sanitary inspectors who took part in the investigation and to the technical and clerical staffs of the two departments concerned who shared between them a burden of routine paper work. Also we wish to thank especially Mr. Herman Chalkley, M.B.E., Registrar of Births and Deaths for Luton, who provided much information about the social classes of the children and helped us in many other ways.

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APPENDIX

EFFECT OF EMPLOYING AN ALTERNATIVE SOCIAL CLASS CLASSIFICATION

A criticism sometimes made of the Registrar General's social class grouping is that Class 3 (skilled workers) includes a large number of black-coated workers whose mortality experience bears a closer resemblance to the lower rates of Class I (the professional group) than it does to the remainder of Class 3. This is not, in our opinion, a justification for combining the black-coated group with the professional classes for the purpose of defining social class differences of mortality and morbidity—for the main object of a social class classification is to afford indices of the influence of differing physical standards of living on mortality and morbidity rates. To transfer to Class 1 the members of Class 3 with favourable mortality rates, but living under the general environmental conditions of Class 3, seems to us to defeat this purpose.

In Appendix Table A (overleaf) we distinguish two sub-divisions of the Registrar General's Class 3 births: 3*a* relating to infants whose fathers are engaged in commercial and clerical pursuits, including shopkeepers and their assistants; and 3 to the remainder.

The tabulation undoubtedly supports the view that the sickness rates of children in Class 3*a* are more akin to Class 1 rates than to those of Class 2 or 3 (remainder). Even in the years when Class 1 rates are higher than Class 3 rates, so also are those of 3*a*.

The social class gradients resulting from the re-combination are shown in Appendix Table B. They may be compared with those given in Table VI (figures in parenthesis in that Table), when, with a single minor exception, it is seen that the conclusions reached on Table VI are unaltered by the recombination proposed. The general picture is still one of absence of any consistent social gradient, the only difference between the two tables being that Appendix Table B shows a downward gradient in the second year of life which was not apparent in Table VI.

APPENDIX TABLE A

DAYS OF ILLNESS PER CHILD FROM ALL CAUSES
Social Class 3*a* compared with Classes 1, 2, and 3 (remainder)

Period of Life	Social Class			
	1	2	3*a*	3
0– mths	0·37	0·93	1·02	1·43
3– mths	1·47	3·36	1·35	2·11
6– mths	1·58	1·60	1·70	2·42
9– mths	—	0·92	1·58	2·23
Total 1st yr	3·42	6·59	5·63	8·25
2nd yr	11·54	7·64	9·57	8·47
3rd yr	6·48	6·99	5·73	6·84
4th yr	10·21	6·63	9·42	8·38
5th yr	5·71	7·61	4·97	6·23

APPENDIX TABLE B

SOCIAL GRADIENT BASED ON "DAYS OF ILLNESS PER CHILD FROM ALL CAUSES" (LEGITIMATE BIRTHS ONLY)
Rate for "All Social Classes" = 100

Period of Life	Social Class				All Classes (except illegitimate)
	1, 2, 3*a*	3 (remainder)	4	5	
0– mths	73·4	111·7	62·5	171·9	100
3– mths	111·7	107·1	71·6	50·8	100
6– mths	78·6	115·2	65·7	95·2	100
9– mths	59·4	110·4	91·6	159·4	100
Total 1st yr	79·6	111·5	73·9	113·5	100
2nd yr	106·8	101·4	89·2	83·7	100
3rd yr	94·9	103·2	97·0	89·9	100
4th yr	99·8	100·4	102·4	90·1	100
5th yr	102·2	104·9	181·5	82·8	100

Brit. J. prev. soc. Med. (1953), 7, 43–59

THE HOUR OF BIRTH

A STUDY OF THE DISTRIBUTION OF TIMES OF ONSET OF LABOUR AND OF DELIVERY THROUGHOUT THE 24-HOUR PERIOD

BY

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(1) Introduction

Whether variations with respect to frequency of births from hour to hour within the course of the day are such as we might expect in any situation in which an immensely complex congeries of circumstances conspires to reproduce the characteristic features of a random sampling system, or whether there is a systematic trend indicative of some predominant agency contributory to a manifest diurnal cycle, are questions of interest both at the administrative level, and from the viewpoint of the biologist in quest of a deeper understanding of the mechanism of labour. The issue has provoked not a few descriptive statistical inquiries of which the outcome has been inconclusive up to date. For reasons which follow, this is not surprising.

(*i*) To undertake any such inquiry with profit it is first necessary to be clear about the operational intention *vis à vis* the method of selecting relevant data. If the end in view is the concern of the *administrator* with the hours of work of the physician or of the midwife, we shall wish to base our conclusions on a representative sample of *all* births. If our aim is to clarify the processes which initiate healthy parturition, we shall wish to exclude all *induced* labours and all labours associated with pathological conditions. In that event, the time of onset rather than the time of delivery is most relevant to a useful decision; but results of enquiries at different times in the same place, or in different places at the same time, might well prove to be discordant in virtue of different fertility levels, if special circumstances attendant on delivery of the first-born effectively mask a manifest trend among later births.

(*ii*) If we take cognizance of the foregoing considerations regarding the selection of data, and more especially of the need to compare time of delivery with time of onset, we must also allow for the possibility of new sources of observational error. To date the time of onset we must rely on the testimony of the mother with a prospect familiar to statisticians in contact with census enumeration, *viz.* clumping of data around fashionable numbers. Furthermore, we shall need to be clear that our criterion of onset is consistent. It will thus be apparent that the customary appeal to tests for goodness of fit will throw little light on a conclusive answer. Any such test employed to date in the context of this enquiry invokes the unique null hypothesis that the distribution is rectangular, subject to randomwise variation due to error as such or to natural variation. We need not take sides in the current controversy concerning the rationale of test procedure, if we here insist that any source of systematic error comparable to clumping of the sort mentioned will prejudice the prescribed interpretation of the test result.

The rejection of the customary null hypothesis does not answer the question: is there a diurnal cycle *sensu stricto*? For its rejection is consistent with an infinitude of alternative hypotheses for a reason which it is pertinent to recognize when assembling data of the sort under consideration, regardless of what attitude we adopt to test procedure in general or the χ^2 test in particular. To speak of a diurnal rhythm implies a day-to-day regularity with respect to events which occur within one and the same 24-hour period. The mere existence of a peak in the course of the latter in a *single* pool of data based on different days does not prove that such a regularity exists. Since we must pool our data in some way, some chronological subdivision of the pool, such as the seasonal split discussed below, is therefore prerequisite to conclusive demonstration that the same pattern recurs on different days.

(*iii*) It is less obvious to the statistician who is not *en rapport* with recent advances in the study of the sex hormones, that the *method of pooling* as well as the method of selecting the data of such an inquiry is eminently relevant to the outcome. If a trend exists in any sense of the term intelligible to the physiologist, we must seek its origin among either or both of two categories of agencies which may conceivably reinforce or conceivably neutralize one another. Physical events such as light and temperature impose on the *material* environment in which parturition occurs a diurnal rhythm, and the normal routine of work, meals, and sleep imposes a diurnal rhythm on the *social* environment. The pattern of neither the one nor the other is consistent throughout the year. Superimposed on each diurnal pattern of

external change are seasonal regularities which may again augment or minimize a systematic trend arising from the sequence of physical or social events incident to the completion of the 24-hour period.

The implications of the possible interplay of seasonal and diurnal events have hitherto received no consideration in this type of inquiry; and they raise issues rarely if ever explicitly recognized in inquiries into seasonal variation of vital statistics in general. It is therefore pardonable to comment on them more fully at this stage, the more so because they will dictate the pooling procedure adopted in what follows. We may first recall that the uterus is subject both to direct reflex control *via* its autonomic innervation, and to neurohumoral control *via* its blood supply. The former is presumptively more especially relevant to the impact of the diurnal cycle of social routine, the latter more especially to the impact of the diurnal cycle of physical milieu.

That the stresses and strains of social routine on the mother throughout the day-time when she is near full-term are not identical in different parts of the calendar year would be too trivial for comment, were it not for the custom of recording seasonal variation of vital statistics by an arbitrary 4-fold split of the calendar year (in contradistinction to the school year, the inland revenue year, and so forth), regardless of the annual lay-out of agencies of presumptive aetiological relevance to the topic. That a seasonal change may mask or magnify a diurnal trend which has its origin in the physical environment is also a possibility which we cannot dismiss lightly, if we reflect on two considerations:

(*a*) the established major role of the pituitary anterior lobe as a pace-maker of the female reproductive cycle;

(*b*) the established role of light with respect to reflex activation of both lobes of the gland and the antagonistic influence of light at opposite ends of the visual spectrum as effective visual stimuli.

From the point of view last stated, we must indeed distinguish between both qualitative and quantitative differences affecting the diurnal cycle of light and darkness at two levels. The exposure of the individual to artificial illumination, and *ceteris paribus* to relatively more visible radiation of long wave length, will be greatest at the winter solstice, when the same is true of daylight. Conversely, the influence of long wave length visible radiation, if any, will be least at the summer solstice; and around the equinoxes conditions relevant to both quantity and quality of solar radiation are identical. Thus comparison of data referable to comparable periods on either side of each equinox offers a unique opportunity of distinguishing the effects of the solar component of the diurnal rhythm of external events from any effects uniquely traceable to the diurnal rhythm of social routine. Owing to the institution of daylight saving, British solar *mean* time is in advance of the social calendar by approximately one hour on September 21, the two being in step on March 21, and the correction for converting mean time into true solar time at these two dates is trivial.*

Thus a diurnal trend predominantly attributable to light should be recognizable in British data referable to a compact community† by a shift of the diurnal peak or the diurnal minimum of just over three-quarters of an hour when we collate records based on data in the vicinity of the two equinoxes. Contrariwise, concordant results referable to the two periods, confirming the real existence of a diurnal period if the peak times are identical, would also point to the influence of agencies referable to the social calendar, *i.e.* to the rhythm of social routine.

The issue with which this communication deals has lately come under discussion in the correspondence columns of the *British Medical Journal* (Simpson, 1952). According to editorial comment, several statistical inquiries during the last 40 years have indicated little, if any, significant difference between the numbers of births taking place between 6 a.m. and 6 p.m., and between 6 p.m. and 6 a.m., the difference in favour of night-time births being at most 2 to 5 per cent. A later correspondent gave figures from Lancashire showing a 10 per cent. excess of births in the 12-hour period 11 p.m. to 11 a.m. A study (de Porte, quoted by Hill, 1948) of births in New York State during the decade 1915–25 by 3-hourly periods gave a distribution of times almost identical with the Lancashire figures, both showing that 54 per cent of births occur between midnight and 3 a.m.

The results quoted are for *all* births including those in which there has been medical or surgical induction of labour or assisted delivery. The writer is not aware of any comparable data about time of onset of labour throughout the 24-hour period. It thus seemed that an examination of fresh data from a more analytical standpoint might be of interest.

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* On March 21, Greenwich *mean* noon occurs at 12.4 p.m. Greenwich solar time. On September 21 it occurs at 11.52 a.m. Greenwich solar time. The difference is 12 minutes.

† *i.e.* a community referable to an area within which variation with reference to longitude is negligible.

The time of birth can be thought of as the result of two sets of processes, those which initiate labour, and those which determine the duration of labour.* Presumably, at each stage, different types of influences may be predominant. For reasons stated, the time of onset of labour, though far less susceptible to accurate observation, should show more clearly than the time of delivery whether in fact variations attributable to one or the other have a detectable effect. The method here adopted is therefore first to examine the distribution of times of onset, and then to explore, in conjunction with duration of labour, the distribution of times of delivery. To define more precisely in what circumstances, if any, a diurnal variation is detectable, and with a view to its interpretation, births were first classified as referable to primigravidae or multigravidae, as domiciliary or institutional, and as taking place at a given time of year. In the first instance, as is described in more detail below, all births accompanied by some circumstance likely to affect the onset or course of labour were excluded. To provide at the same time information directly relevant to the issue as it presents itself to the administrator, Tables will also be given covering live and still births of all types.

(2) Material and Methods

The Public Health Department of the City of Birmingham receives, for resident live and still births occurring in the city, an Antenatal and Delivery Record completed by the midwife in the case of domiciliary births, and by a member of the hospital staff in the case of hospital births. These records are copied on to the Health Visitors' Records, and the original delivery records were made available to us by the courtesy of the Department of Maternity and Child Welfare.† They call explicitly for the date and exact time of onset and delivery. The duration of labour to the nearest hour is computed from these times and recorded by the office. Some hospital forms, however, give the duration of labour to the nearest minute or hour together with the time of delivery. These delivery records have been received for live births since January 1949 and for stillbirths since January 1951. Rendition has not been complete and is estimated at about 90 per cent. for live births during the period covered by the inquiry. About half the missing records are those of nursing-home and private-doctor patients and these constitute a possible source of bias. Among the delivery records available, time of onset or delivery was not given or was ambiguous in about 6 per cent. Rendition was complete for stillbirths in 1951, in that a record existed, but the absence of some material particular reduced the usable records to 93 per cent. of the total. The total number of live and still births for which times of onset and delivery were tabulated exceeded 16,000.

Of the two times recorded, the exact moment of delivery has legal significance, and the method of obtaining the information suggests that in general the times recorded should be reasonably accurate. In the case of babies born before the arrival of a medical attendant, information is hearsay and hence less accurate. The times of onset are much less reliable. The onset of labour is defined in Birmingham practice, both domiciliary and hospital, as the first painful contraction of the uterus followed by others at regular intervals. Yet it has seemed that hospitals may sometimes regard rupture of the membranes as constituting onset. In addition to ambiguities surrounding the actual event, the observer is the mother only and hence the record is a stage further removed from first-hand recording. As a result there are indications in part of the data of clumping at even hours. Whether in addition biased errors occur can only be determined, if at all, from the results.

The delivery records contain particulars of plurality, the antenatal record, the type of labour, and the condition of the infant. As indicated above, a number of records were excluded where circumstances seemed likely to affect materially the onset or course of labour. Those excluded were:

(*a*) stillbirths;

(*b*) second twins, second and third stillbirths;

(*c*) antenatal complications: toxaemia, positive Wassermann, rubella, non-toxic ante-partum haemorrhage, pyelitis, hydramnios, endocrine dysfunction;

(*d*) medical or surgical induction or delivery;

(*e*) all presentations other than vertex;

(*f*) all congenital malformations of the infant.

The records were complete in respect of plurality, and very nearly so in respect of type of labour, presentation, and congenital malformations. The antenatal record was less complete, and some of the named complications may have been missed, but these, together with the complications not rejected,

* In this inquiry, duration of labour includes the first and second stages only. It ends with the delivery of the foetus.

† In an inquiry of this sort, it does not always happen that the investigator can speak with first-hand knowledge of the reliability of rendition and methods of recording the data employed. During her tenure as Chief Statistical Officer to the City Corporation, at the request of the Department of Maternity and Child Welfare, the author designed new records (Charles, 1951) and supervised, on behalf of the department, the inauguration of a new machinery of rendition.

were few in number. The association between antenatal complications and medical or surgical intervention, etc., ensured that the more complete screening of the rest of the record would eliminate most of the missed antenatal complications. Hence the cases analysed, hereafter referred to as "selected cases", consist very largely of pregnancies and labours free from any pathological disturbance up to the time of delivery, except for the minor common complaints, anaemia, and varicose veins.

The selected cases fall into two groups. First all the 1950 and 1951 cases falling in the 4-weekly periods round the solstices and equinoxes were examined with a view to possible effects of light intensity. As numbers of births fall off towards the end of the year, these were supplemented by all remaining cases in August-September and November-December. Parity was obtained for the second set of cases. This item is not given on the delivery records so each record had to be matched with its corresponding punch-card in the files of the Maternity and Child Welfare Department. The considerable labour involved unfortunately limited the numbers available for analysis by parity. All records were sorted as domiciliary or institutional births, the former including "born before arrival" and ambulance deliveries.

(3) Time of Onset

(*a*) *All Selected Cases.*—As a background to the differences found among different types of births, Table I and Fig. 1 show the percentage distribution by times of onset of labour of all births selected as described above. The raw data for Table I and other percentage tables of time of onset are given in Appendix Table A (p. 59). The distribution shows a clearly marked peak at 2 a.m. to 3 a.m. In the 6-hour period 11 p.m. to 5 a.m., 37 per cent. of labours began compared with the expected 25 per cent. The greatest difference between night and day is shown by taking the 12-hour period 9 p.m. to 9 a.m. with 62 per cent. of all onsets, as compared with 38 per cent. of onsets between 9 a.m. and 9 p.m. The point of minimum onset is less clearly marked but occurs in this distribution at 1 p.m. to 2 p.m. There are minor peaks at 2 p.m., 6 p.m., 11 p.m., and 6 a.m. To a small extent these peaks reflect the clumping at even numbers found in part of the data but there are indications of a 4-hourly periodicity, the significance of which is obscure. To show the distribution without these

Table I

PERCENTAGE ONSET OF LABOUR BY TIME OF DAY SELECTED CASES

Time of Day	Percentage	Time of Day	Percentage
12 Midnight	5·2	12 Noon	2·7
1 a.m.	6·6	1 p.m.	2·4
2 a.m.	7·4	2 p.m.	3·7
3 a.m.	6·1	3 p.m.	3·1
4 a.m.	5·6	4 p.m.	3·3
5 a.m.	3·9	5 p.m.	3·2
6 a.m.	4·5	6 p.m.	3·9
7 a.m.	3·9	7 p.m.	3·1
8 a.m.	3·7	8 p.m.	3·5
9 a.m.	3·5	9 p.m.	3·9
10 a.m.	3·0	10 p.m.	5·3
11 a.m.	2·8	11 p.m.	5·7

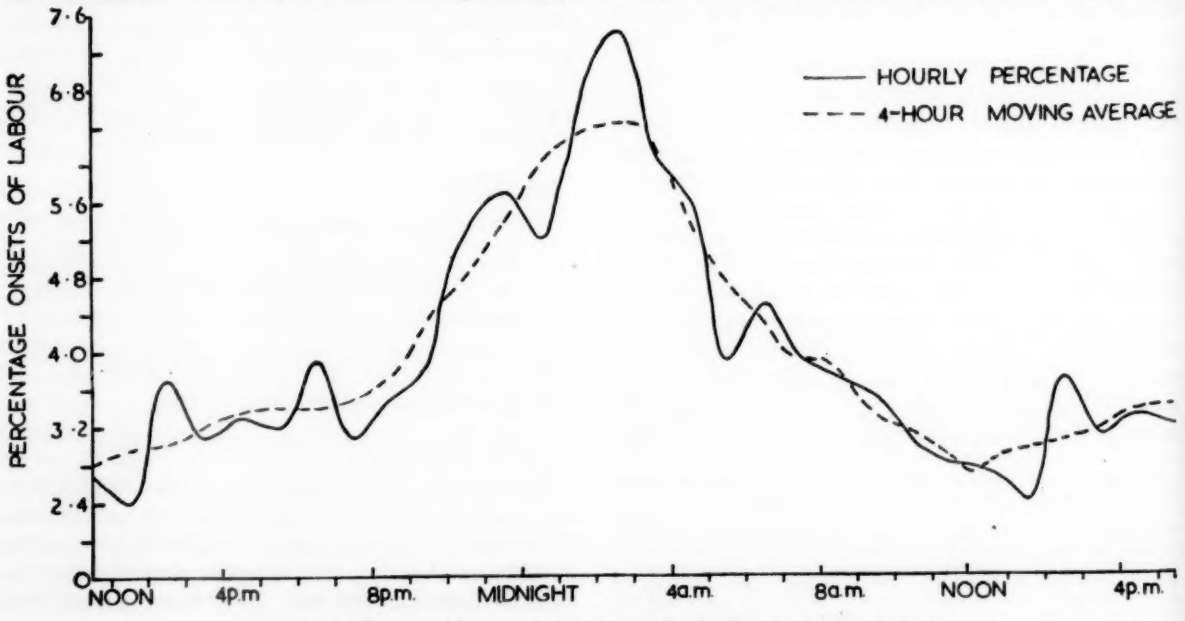

Fig. 1.—Percentage distribution of times of onset of labour in all selected births.

subsidiary peaks, Fig. 1 gives a 4-hourly moving average. The main features of Fig. 1 are found in all the sub-classes of this group of cases. Apart from irregularities which may be due to small numbers, they differ, as will be seen, in the flatness of the curve and in the proportions of onsets which occur before the 2 a.m. peak.

(*b*) *Parity.*—Appendix Table A exhibits four groups of data for each of which we have separate records referable respectively to primigravidae and to others. Parity in this inquiry means number of previous live and still births, so that primigravidae are those women who have not previously had a pregnancy resulting in a viable foetus.

All eight distributions show a peak similar to that in Fig. 1. In six it falls in the same place, 2 a.m. to 3 a.m., and in the other two it falls between midnight and 1 a.m., and between 1 a.m. and 2 a.m. The minimum, being less clearly defined and involving sometimes very small numbers, is much more scattered, but all fall in the daytime, between 8 a.m. and 10 p.m. The greatest difference between the unsmoothed distributions is shown by the domiciliary onsets in August (Fig. 2). The differences between primigravidae and others are most simply shown by percentages in 6-hour periods (Table II). In the periods of maximum and minimum onset, 11 p.m. to 5 a.m. and 11 a.m. to 5 p.m., the differences between primigravidae and others are quite consistent, the former showing higher percentages in the maximum period and lower in the minimum. The shapes of the distributions are so much steeper in primigravidae, that in every case but one they also show lower percentages in the remaining 6-hour periods.

TABLE II
PERCENTAGE TIMES OF ONSET BY PARITY—6-HOUR PERIODS

Time	Parity	Domiciliary		Institutional	
		Aug. Per cent.	Nov. Per cent.	Aug. Per cent.	Nov. Per cent.
11 p.m. to 5 a.m.	Primigravidae	48·1	42·0	38·6	37·9
	Multigravidae	36·4	37·7	34·6	34·3
5 a.m. to 11 a.m.	Primigravidae	21·0	21·8	23·0	19·9
	Multigravidae	24·9	22·5	24·9	20·2
11 a.m. to 5 p.m.	Primigravidae	13·2	15·5	16·7	18·4
	Multigravidae	17·4	17·2	17·7	24·2
5 p.m. to 11 p.m.	Primigravidae	17·7	20·7	21·7	23·8
	Multigravidae	21·3	22·6	22·8	21·3

Of the minor periodicities mentioned earlier, clumping at even numbers is shown only by the domiciliary multigravidae. There are indications of a 4-hourly period throughout the domiciliary births and among the institutional primigravidae. To show parity differences free from minor periodicities and irregularities, the four percentages for

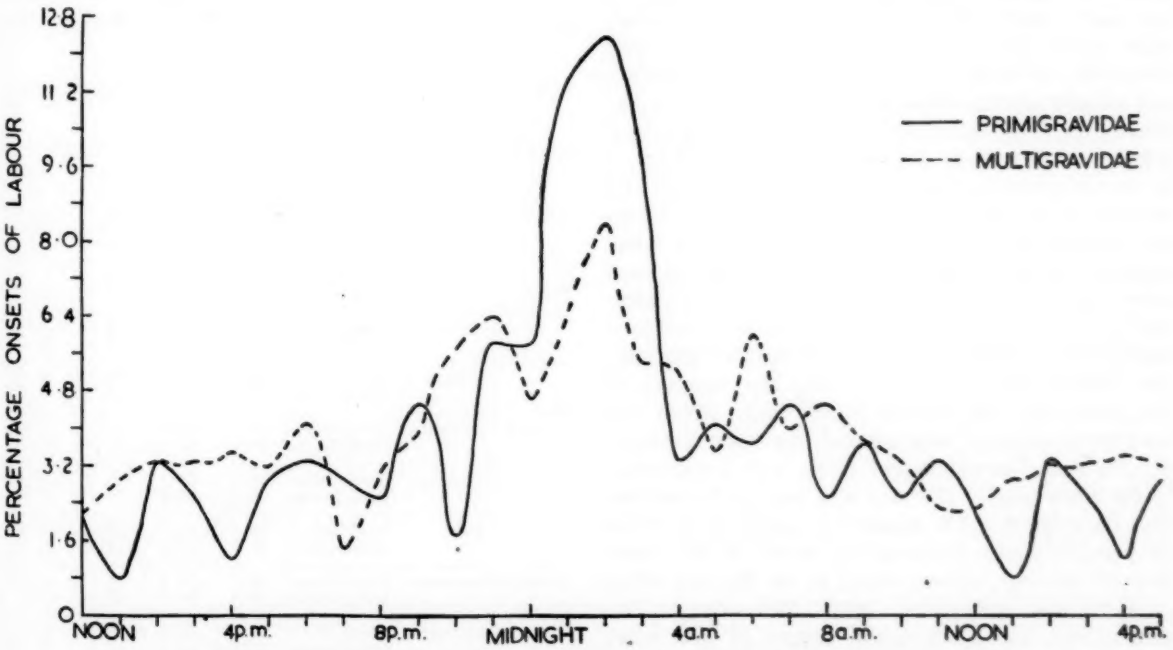

FIG. 2.—Percentage distribution of times of domiciliary onsets of labour in the month of August by parity.

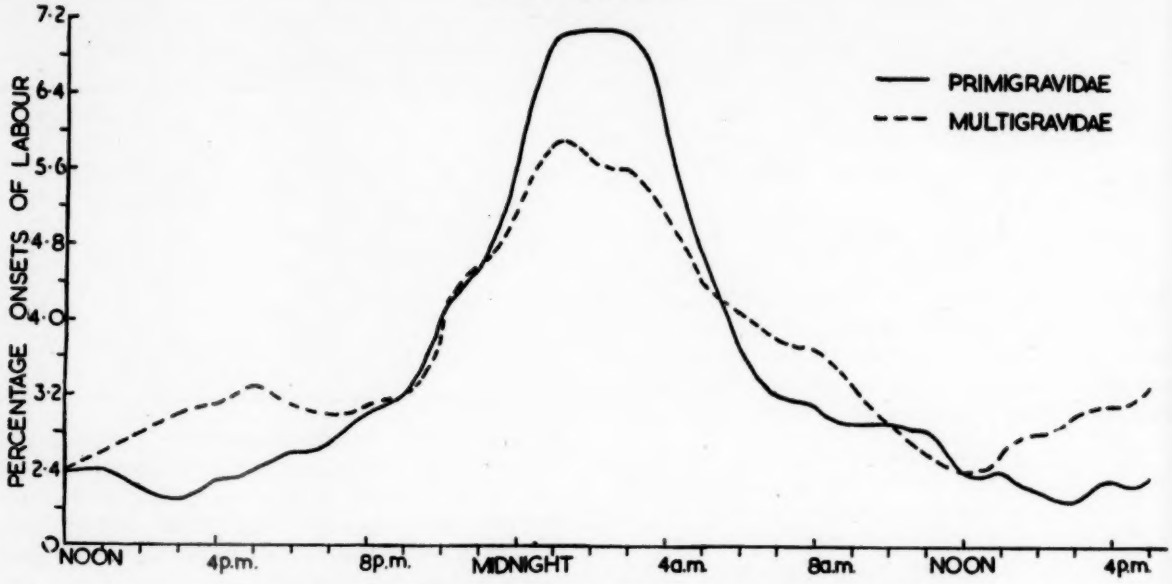

FIG. 3.—Percentage distribution of times of onset of labour by parity. 4-hour moving averages.

each parity sub-class were averaged and a four-hour moving average computed (Fig. 3). The graph shows the greater steepness of the primigravidae distribution and also indicates that the late day rise in times of onset starts earlier in multigravidae, so that there is an excess between 2 p.m. and 6 p.m.

(*c*) *Domiciliary and Institutional Births.*—Since the selection of cases excludes most of those with manifest medical indications for hospitalization, and since nearly all labours would start at home, there would seem to be no reason to expect any difference in times of onset between domiciliary and hospital births when parity is controlled. Nevertheless, as Table III shows, the domiciliary distributions are consistently steeper, though the difference is not so great as that between primigravidae and multigravidae. A higher proportion of first births are hospitalized so that when all parites are taken together the two effects noted tend to cancel each other out. The lower half of Table III shows domiciliary and institutional differences without distinction of parity. In the early part of the year, the domiciliary distributions are the steeper; in the latter part the reverse is the case. While the number of hospital beds remains the same throughout the year, the number of births is at a maximum in the early part of the year and least in November and December. This suggests a higher proportion of primigravidae delivered at home in the early part of the year, as was found to be the case when August was compared with November. The domiciliary and institutional figures of the latter part of Table III are thus consistent with previous results. For comparison with the previous section, Fig. 4 (opposite) shows unsmoothed percentage distributions for primigravidae in August, and Fig. 5 (opposite) 4-hour moving averages for domiciliary and institutional primigravidae computed as before.

(*d*) *The Seasons.*—Although elucidation of the possible effects of variation with reference to intensity and amount of light, as also to the relative long wave-length content, was a major pre-occupation of the author's method of sub-dividing the

TABLE III

PERCENTAGE DISTRIBUTION—TIMES OF ONSET—6-HOUR PERIODS

Domiciliary v. Institutional

Parity	Month	Type of Case	11 p.m. to 5 a.m. Per cent.	5 a.m. to 11 a.m. Per cent.	11 a.m. to 5 p.m. Per cent.	5 p.m. to 11 p.m. Per cent.
Primigravidae	August	Domiciliary	48·1	21·0	13·2	17·7
		Institutional	38·6	23·0	16·7	21·7
	November	Domiciliary	42·0	21·8	15·5	20·7
		Institutional	37·9	19·9	18·4	23·8
Multigravidae	August	Domiciliary	36·4	24·9	17·4	21·3
		Institutional	34·6	24·9	17·7	22·8
	November	Domiciliary	37·7	22·5	17·2	22·6
		Institutional	34·3	20·2	24·2	21·3
All Parities	March	Domiciliary	36·2	25·3	15·8	22·7
		Institutional	36·1	18·2	20·3	25·4
	June	Domiciliary	38·7	21·7	17·0	22·6
		Institutional	37·2	21·4	18·2	23·2
	September	Domiciliary	34·7	23·5	18·9	22·9
		Institutional	35·5	20·7	18·6	25·2
	December	Domiciliary	34·3	24·5	19·1	22·1
		Institutional	36·7	22·7	16·2	24·4

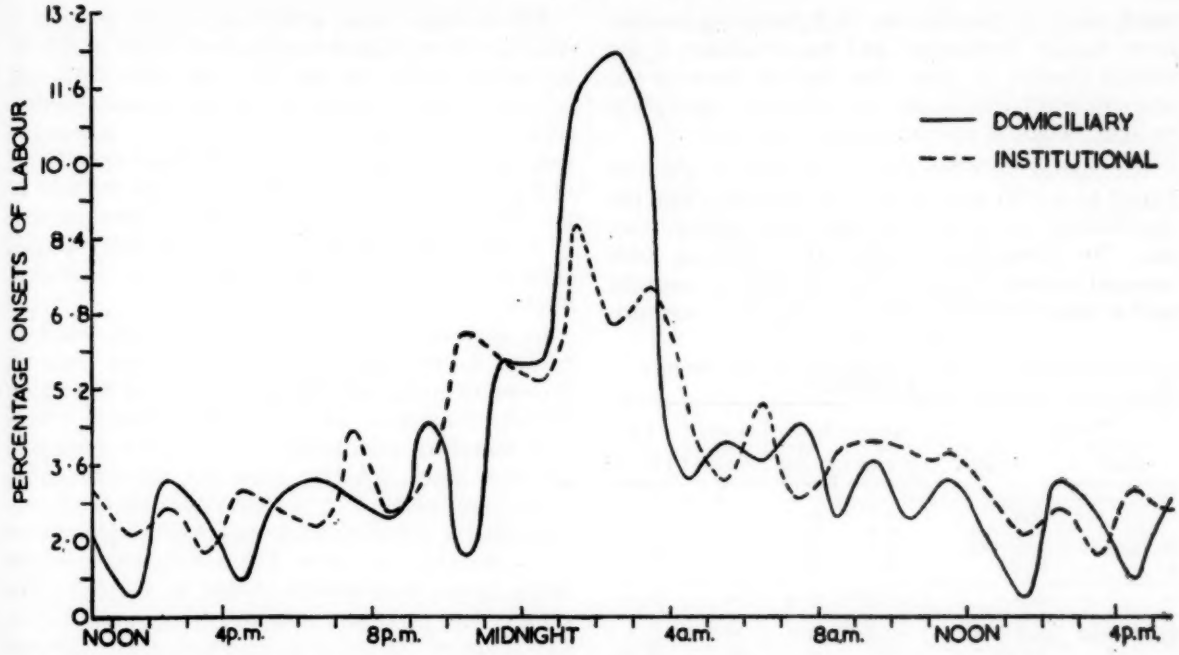

FIG. 4.—Percentage distribution of times of onset of labour in primigravidae. Domiciliary and institutional onsets in the month of August, unsmoothed.

data, the outcome has been to show that any seasonal effect is small compared with effects associated with parity and place of delivery. The daily curve with a minimum about noon and a maximum about 2 a.m. is clearly a response to a socially determined daily rhythm largely independent of seasonal influences. For the reason stated above, we should be able to show a shift of

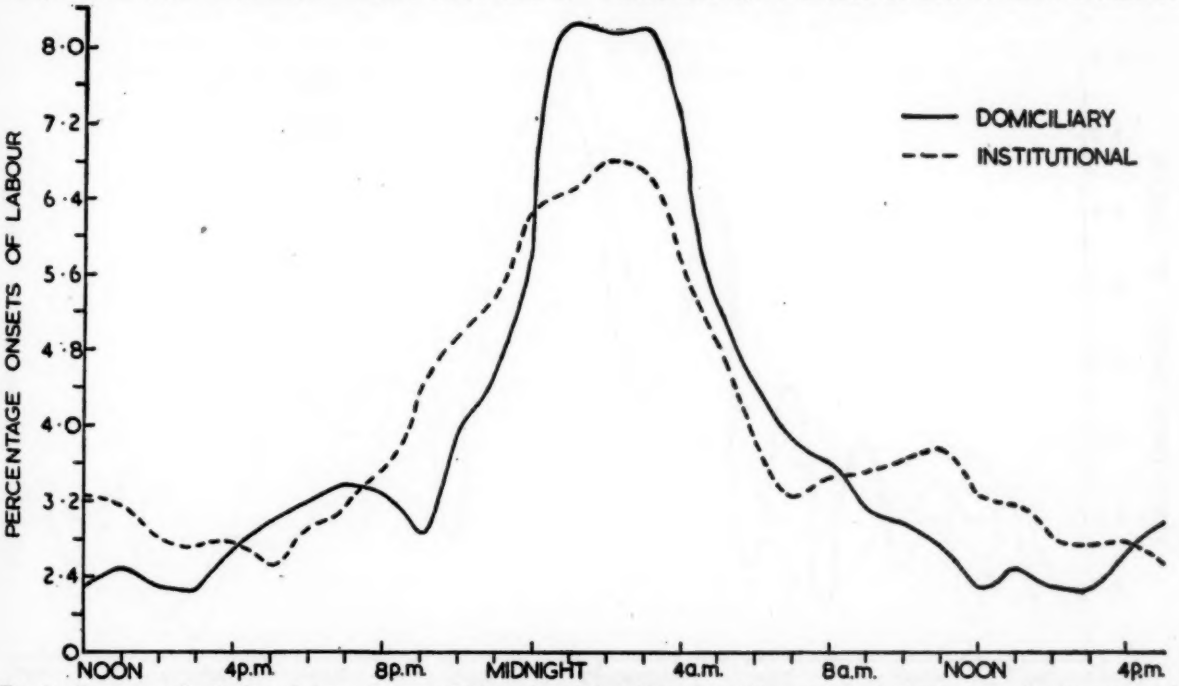

FIG. 5.—Percentage distribution of times of onset of labour in primigravidae. Domiciliary and institutional onsets in the month of August, 4-hour moving averages.

nearly one hour between the daylight-saving months June, August, September, and the remainder, if the diurnal rhythm of onset time had its basis in the neurohumoral mechanism of pituitary activation by light. There is no trace of any such shift.

The figures for 6-hourly periods already given in Tables II and III show that for domiciliary cases the distribution for August is somewhat steeper than that for November. Table IV, covering four seasonal periods, suggests that the summer months tend to show a sharper peak than the winter months.

TABLE IV

PERCENTAGE DISTRIBUTION—TIMES OF ONSET—6-HOUR PERIODS

Type of Case	Season	11 p.m. to 5 a.m. Per cent.	5 a.m. to 11 a.m. Per cent.	11 a.m. to 5 p.m. Per cent.	5 p.m. to 11 p.m. Per cent.
Domiciliary	June	38·7	21·7	17·0	22·6
	Aug.–Sept.	36·8	23·9	17·8	21·5
	Nov.–Dec.	36·6	23·3	17·9	22·2
	March	36·2	25·3	15·8	22·7
Institutional	June	37·2	21·4	18·2	23·2
	Aug.–Sept.	36·5	22·5	17·1	23·9
	Nov.–Dec.	36·3	21·2	19·3	23·2
	March	36·1	18·2	20·3	25·4

This point is further illustrated by Fig. 6, which compares the unsmoothed distributions for domiciliary cases in June and March, and by Fig. 7 (opposite), which gives 4-hourly averages for the four seasons.

The summer-winter difference may be possibly a response to red light bringing about onset of labour somewhat earlier in the day and thus flattening the curve. The absence of clear-cut seasonal differences makes any such suggestion necessarily speculative particularly in the artificial conditions of life in a large smoke-polluted city. In the light of the present inquiry, we suggest that an investigation of a sufficient number of rural domiciliary births, classified by parity, might prove of biological interest.

(*e*) *Rejected Cases and Stillbirths.*—As described earlier, 3,794 cases were omitted from analysis because of some features likely to affect the course of labour more or less adversely. Though a very heterogeneous assemblage, the picture presented by these cases, together with 386 stillbirths, may prove suggestive. Fig. 8 (opposite) shows the unsmoothed distributions of the rejected cases compared with those analysed above. The distribution as well as being flatter, is markedly shifted to the left. The peak is now at 10 p.m. and the minimum at 8 a.m. The shape of the curve is obviously quite different from any encountered previously.

Fig. 9 (overleaf) gives 4-hour moving averages for the rejected cases, sub-divided into domiciliary and institutional, and for the stillbirths. The stillbirth distribution has shifted still further to the left, and there is a suggestion of bimodality, in that,

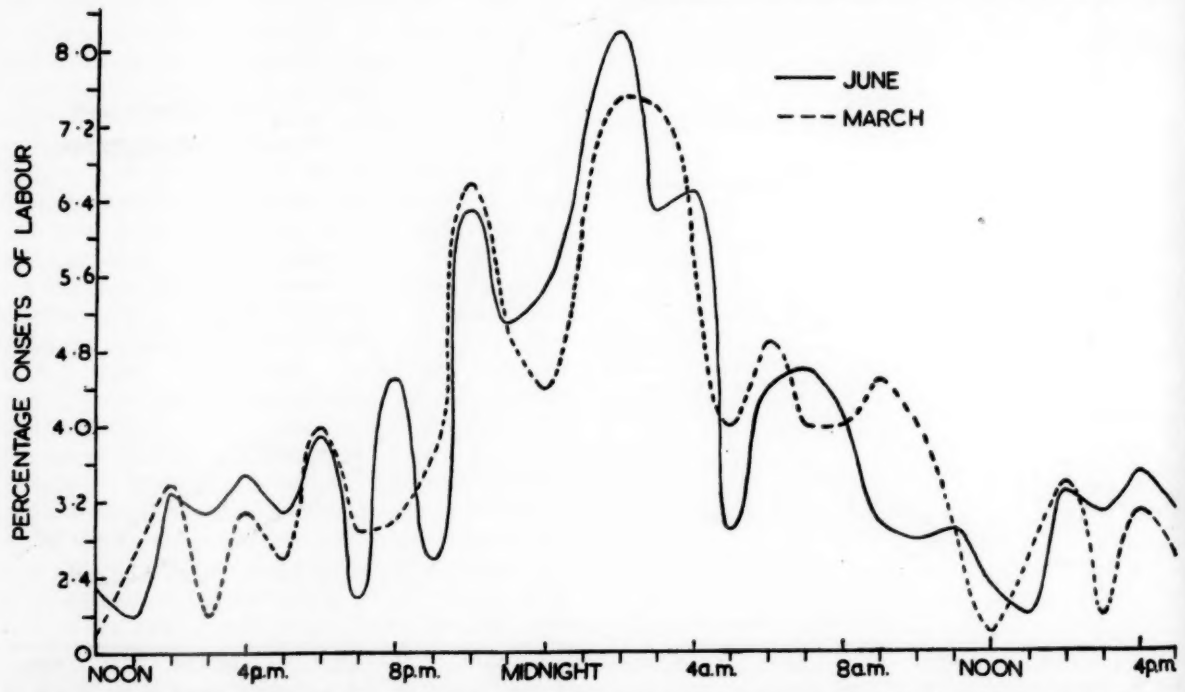

FIG. 6.—Percentage distribution of times of onset of labour. Domiciliary onsets for the months of March and June, unsmoothed.

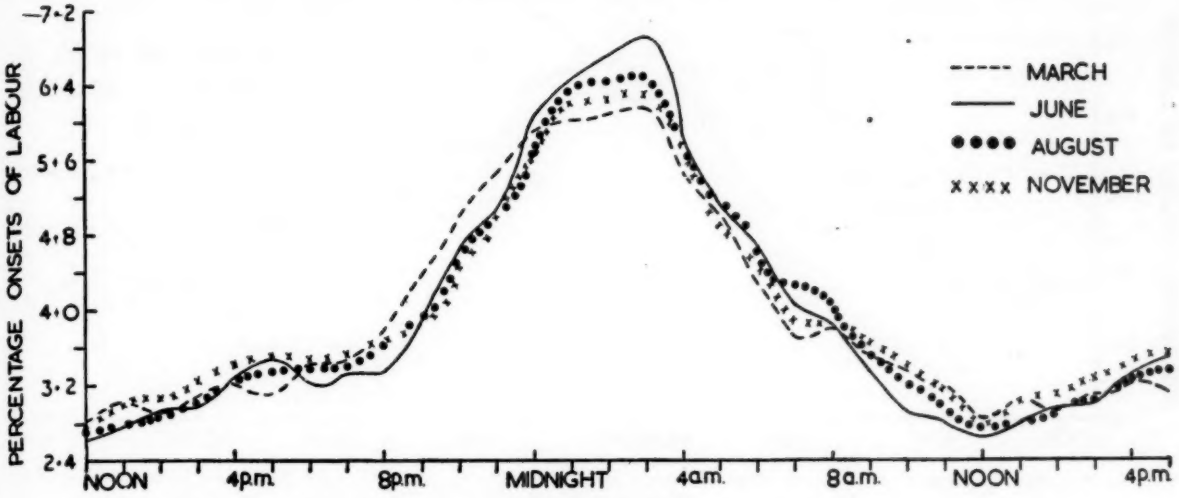

FIG. 7.—Percentage distribution of times of domiciliary onsets of labour in March, June, August, and November.

superimposed on the maximum period found previously round 2 a.m., there is a high frequency group of onsets between 5 p.m. and 11 p.m. The tendency for onset to occur earlier with what may possibly be increasing severity of pathology is shown in Table V, which gives the percentages in two of the 6-hour periods used previously.

TABLE V

PERCENTAGE DISTRIBUTION—TIMES OF ONSET REJECTED CASES OR STILLBIRTHS—6-HOUR PERIODS

Type of Case	5 p.m. to 11 p.m. Per cent.	11 p.m. to 5 a.m. Per cent.
Selected	22·9	36·7
Domiciliary Rejected ..	25·0	33·8
Institutional Rejected ..	27·2	30·4
Stillbirths	30·5	29·7

(4) TIME OF DELIVERY

(*a*) *All Selected Cases.*—The distribution of durations of labour in Birmingham over the relevant period is known. It is extremely skew with the mode for primigravidae at about 8 hours, and for multigravidae at about 4 hours. In the present inquiry, the 24-hour cycle is being investigated, so that

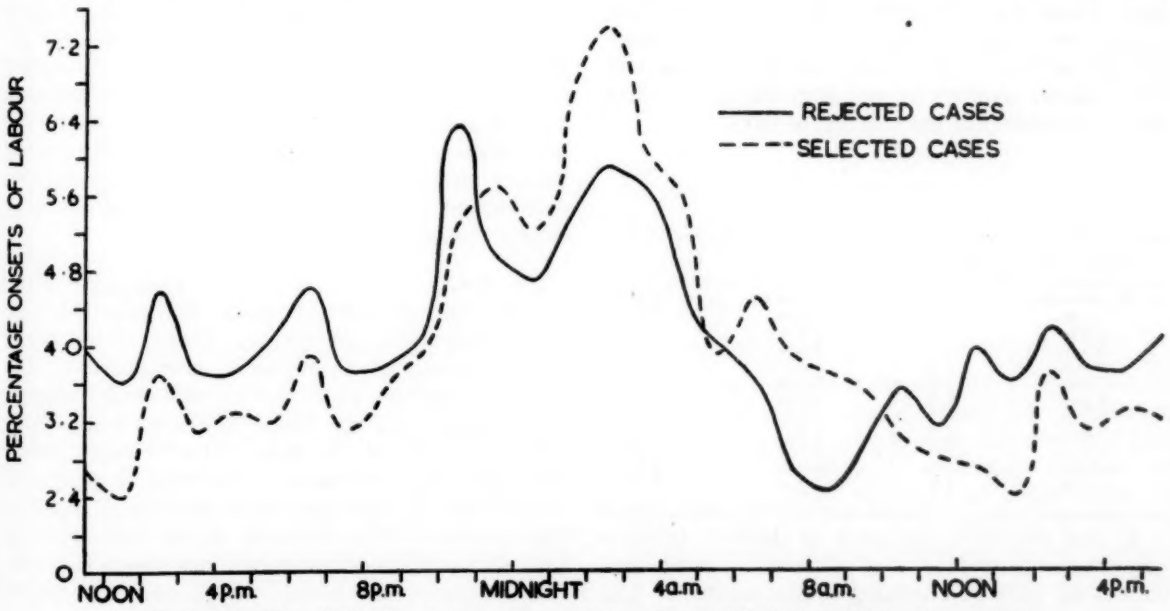

FIG. 8.—Percentage distribution of times of onset of labour in selected and rejected births. Unsmoothed.

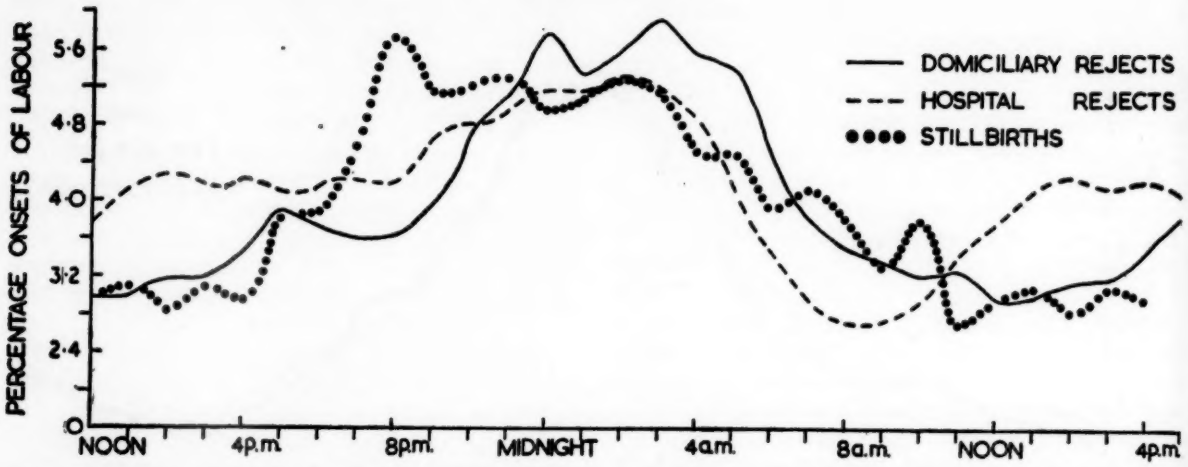

FIG. 9.—Percentage distribution of times of onset of labour in rejected hospital births, rejected domiciliary births, and stillbirths. 4-hour moving averages.

durations of 1 hour and 25 hours, etc., are equivalent. With this in mind, we might suppose that the distribution of delivery times could be predicted from that of times of onset. We should expect to see a much flatter curve with peaks, if any, at about 6 a.m. and 10 a.m., since the modal time of onset was almost invariably at 2 a.m. The absence of clumping, due to more accurate recording of delivery times, would also lead to greater scatter.

The actual distribution found for the selected cases whose times of onset are given in Fig. 1 and Table I is shown in Table VI (below) and Fig. 10 (opposite). Appendix Table B (p. 59) gives the raw data. There are a few differences in total numbers, due to times of delivery being available without times of onset, and very occasionally, the reverse situation. The numbers involved are not large enough to affect the comparability of the two sets of data.

TABLE VI

PERCENTAGE DELIVERIES BY TIME OF DAY

(Selected Cases)

Time of Day	Per cent.	Time of Day	Per cent.
12 Midnight	4·1	12 Noon	3·8
1 a.m.	4·3	1 p.m.	3·8
2 a.m.	5·0	2 p.m.	3·6
3 a.m.	5·5	3 p.m.	3·6
4 a.m.	5·2	4 p.m.	3·7
5 a.m.	4·7	5 p.m.	3·7
6 a.m.	4·9	6 p.m.	3·7
7 a.m.	4·8	7 p.m.	3·6
8 a.m.	4·4	8 p.m.	3·4
9 a.m.	3·9	9 p.m.	4·0
10 a.m.	3·6	10 p.m.	3·8
11 a.m.	4·0	11 p.m.	4·9

As was expected, the curve of delivery times is very much flatter than that of times of onset, and there is no trace of clumping at even numbers. The 12-hour period containing the most deliveries is at night between 9 p.m. and 9 a.m., with 55·6 per cent. of all deliveries. Thirty per cent. occur in the 6-hour period, 2 a.m. to 8 a.m., instead of the expected 25 per cent.

When, however, we compare the peak period with the peak times of onset, it is seen to be different from expectation. Both the unsmoothed curve and the 4-hour moving average show a maximum only one hour later than the maximum time of onset. In describing the expected times of delivery, the assumption was made that there was no reason to expect differences in duration according to time of onset. Clearly a peak delivery time at about 3 a.m. is inconsistent with this assumption. The situation can be seen more clearly when we examine primigravidae and multigravidae separately. To verify that deductions from the known parity sub-classes are applicable to the whole group, Fig. 10 also shows the percentage distribution of all cases with known parities. In so far as the maxima are concerned, the distribution of the smaller class corresponds very closely to that of the whole.

(*b*) *Parity*.—Figs 11 and 12 (opposite) show distributions of delivery times for primigravidae and multigravidae respectively. Owing to the much greater spread of durations in primigravidae, the curve of delivery times is, as one would expect, much flatter, and the longer durations bring more deliveries into the day-time. The 12-hour period with most first deliveries is between 3 a.m. and 3 p.m. with 53·2 per cent. of all deliveries. Twenty-eight per cent. occur between 6 a.m. and 12 noon. In fact, for practical purposes, one might say that first deliveries are evenly distributed throughout the 24 hours.

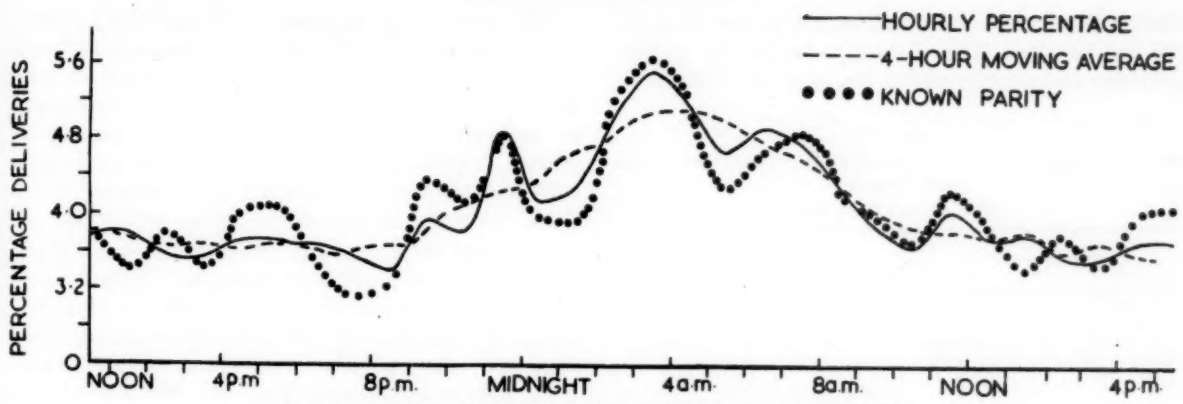

FIG. 10.—Percentage distribution of times of delivery in all selected births.

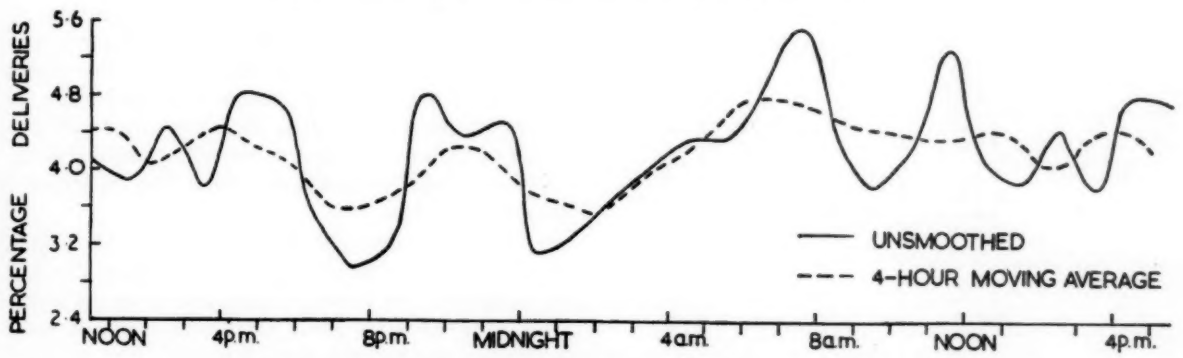

FIG. 11.—Percentage distribution of times of delivery of primigravidae, unsmoothed and 4-hour moving averages.

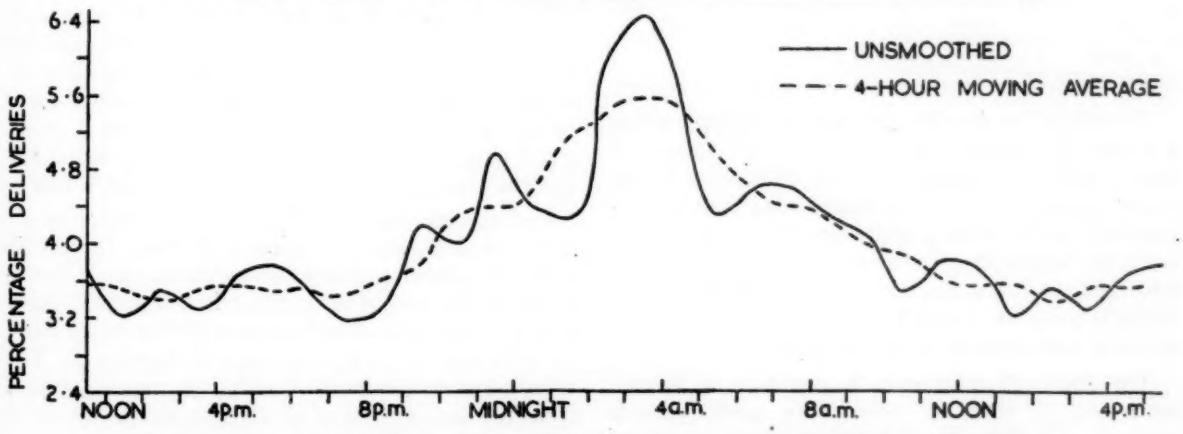

FIG. 12.—Percentage distribution of times of delivery of multigravidae, unsmoothed and 4-hour moving averages.

Multigravidae show a more definite maximum. The 12-hour period with the most deliveries is between 9 p.m. and 9 a.m., which includes 57·5 per cent. of all deliveries. In the 6-hour period 2 a.m. to 8 a.m. are found 31·4 per cent. of the deliveries. Both distributions show the discrepancy referred to previously, in that the hour of maximum occurrence is some 3 hours earlier than would be expected from the times of onset.

The relationship between time of onset and duration of labour is a complex one. What seems to determine the form of the delivery time curve is the modal duration for each time of onset, but, owing to the small numbers at single hours, the mode in this context can be extended to mean the 3-hour period with the largest number of durations. If all other durations are disregarded, and delivery times calculated from these durations alone, a

distribution can be obtained which is very close to the actual one. The 3-hourly modes for primigravidae and multigravidae are given in Table VII.

TABLE VII
MODAL DURATIONS OF LABOUR FOR DIFFERENT TIMES OF ONSET
(25 hours = 1 hour, etc.)

Primigravidae		Multigravidae	
Modal Duration (hrs)	Time of Onset	Modal Duration (hrs)	Time of Onset
5–7	12 Midnight	1–3	5 a.m.
6–8	1 a.m. 3 a.m. 4 a.m. 2 p.m. 8 p.m. 10 p.m.	2–4	1 a.m.
		3–5	12 Midnight 4 a.m. 8 p.m. 11 p.m.
7–9	2 a.m. 6 p.m. 11 p.m.	4–6	2 a.m. 3 a.m. 6 a.m. 7 a.m. 9 a.m. 11 a.m. 9 p.m. 10 p.m.
8–10	8 a.m. 9 a.m.		
9–11	5 a.m. 11 a.m. 1 p.m. 5 p.m. 7 p.m.	5–7	5 p.m. 7 p.m.
		6–8	10 a.m. 12 Noon 2 p.m. 3 p.m. 4 p.m. 6 p.m.
10–12	6 a.m. 7 a.m. 10 a.m.		
11–13	12 Noon 1 p.m. 3 p.m.	7–9	8 a.m.
12–14	9 p.m.	8–10	1 p.m.
14–16	4 p.m.		

To explain the distributions in detail would require a ponderous amount of arithmetic, but Table VII should suffice to indicate that the antedating of the major peaks for both primigravidae and multigravidae results from a piling-up of short durations from two directions. In labours starting at 11 p.m., midnight, and 1 a.m., the mode is reached early, but in labours starting at 4 a.m. to 7 p.m. it is reached late and both contribute to the maximum found.

The apparent differences in duration of labour according to time of onset have some general interest. So Figs 13 and 14 (opposite) compare frequencies of duration according to whether onset occurs during the night (defined as the 12-hour period 8 p.m. to 8 a.m.) or during the day. The difference is most clearly marked for multigravidae, but both parity groups show a greater frequency of short durations. This is confirmed by the mean duration of labour:

primigravidae: night, 15·9 hrs; day, 17·2 hrs,
multigravidae: night, 9·6 hrs; day, 10·5 hrs.

The explanation suggests itself that when labour starts during sleep the first few contractions may not awake the subject and thus the duration may appear shorter. This would, however, hardly seem to account for the shorter durations starting at 10 and 11 p.m., and it might be that when the day's activities are over the uterus is more relaxed and a slight advantage gained in the course of labour.

Since the pattern of delivery times is so different for primigravidae and multigravidae, detailed study of domiciliary compared with institutional births would be fruitless with the relatively small numbers available after parities have been distinguished. It is also worth noting that the distributions of delivery times are more irregular than those of onset times, possibly because of the superimposition of widely varying duration times upon a comparatively simple pattern of onset times, so that the order manifest in the smallest groups of onset times is less easy to detect. We shall, therefore, after examining the rejected cases and stillbirths, present Tables of mainly administrative interest showing the delivery times of all births.

(*c*) *Delivery Times for All Births.*—Fig. 15 (opposite) shows 4-hour moving averages for rejected cases and stillbirths. As would be expected from the onset times, deliveries in both types are more evenly distributed throughout the 24 hours. For rejected cases, 52 per cent. of deliveries occur between 9 p.m. and 9 a.m., and 28 per cent. between 11 p.m. and 5 a.m. This is but little in excess of a uniform hourly distribution. For stillbirths the maximum 12-hour period is from noon to midnight with 54 per cent. of deliveries; 30 per cent. occur between 1 p.m. and 7 p.m., but the number of cases is so small (386) that the afternoon peak may be of little significance.

For administrative purposes, the incidence of all deliveries irrespective of type is of interest. Table VIII (overleaf) gives frequencies of domiciliary and institutional births and of all births taken together. Live births comprise all recorded cases during stated parts of 1950 and 1951, as described in Section 2. The corresponding numbers of stillbirths were estimated from the distribution of all 1951 stillbirths found in that year.

(*i*) Taking all births together, the 12-hour period with the most deliveries is from 9 p.m. to 9 a.m. (54·8 per cent.). The peak hour is 3 to 4 a.m., and 29 per cent. of deliveries occur in the 6-hour period 2 to 8 a.m.

(*ii*) The domiciliary distribution is somewhat steeper. For the same period, 55·5 per cent. of domiciliary deliveries occur at night compared with 54·1 per cent. of institutional deliveries. In the peak 6-hour period are found 30·3 per cent. domiciliary deliveries and 27·9 per cent. institutional.

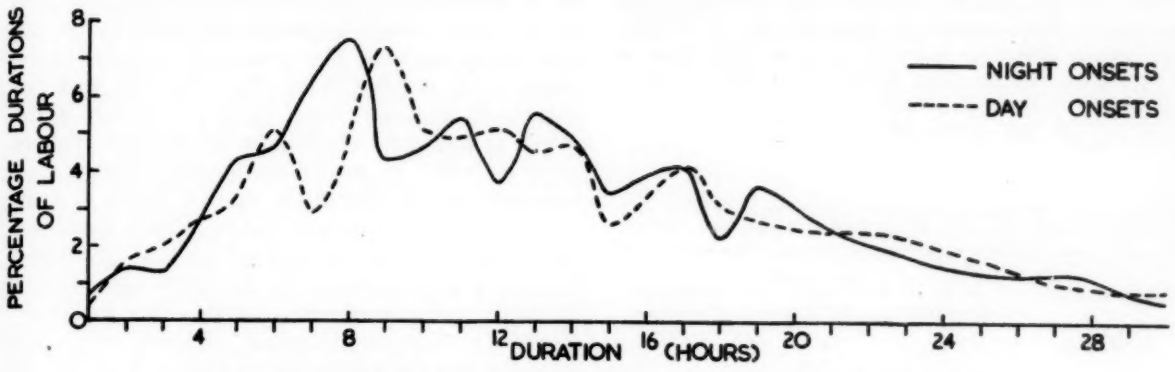

FIG. 13.—Percentage distribution of durations of labour by day and night onset in primigravidae.

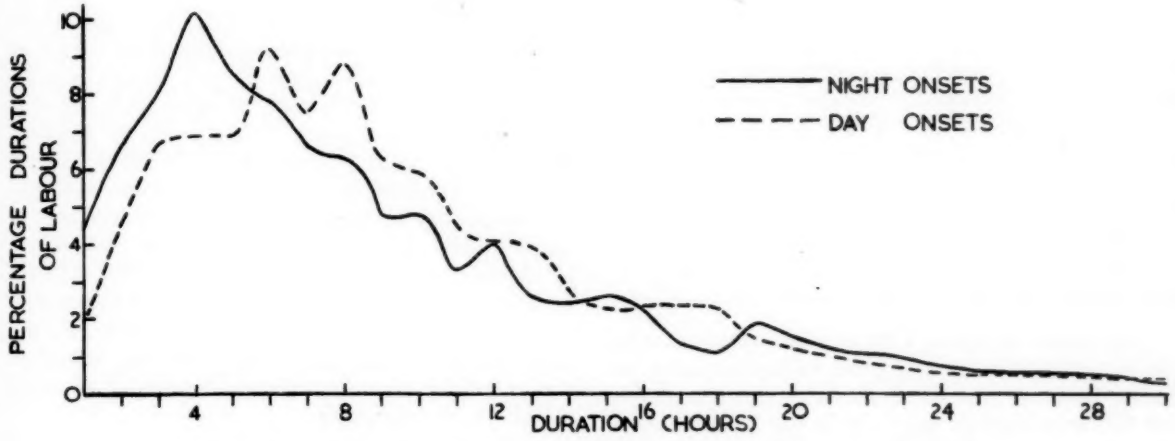

FIG. 14.—Percentage distribution of durations of labour by day and night onset in multigravidae.

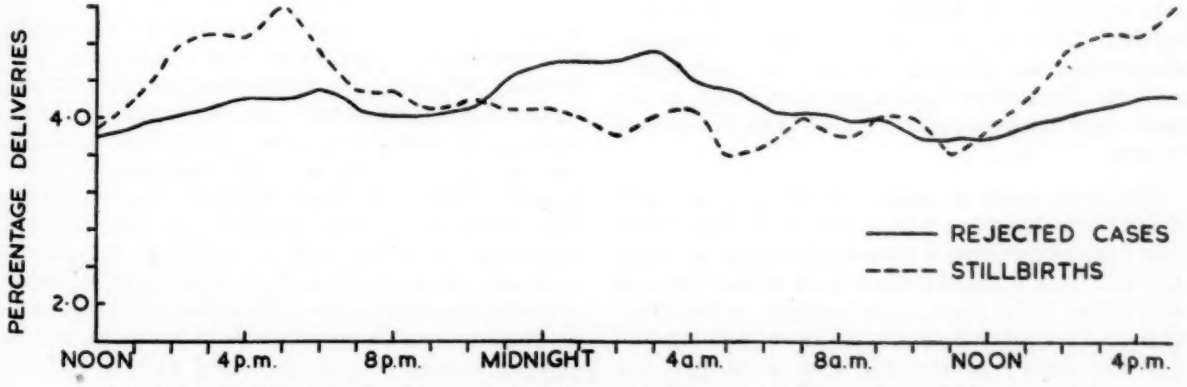

FIG. 15.—Percentage distribution of times of delivery in all rejected cases and stillbirths. 4-hour moving averages.

(*iii*) The domiciliary deliveries are also later. The maximum 12-hour period is from 10 p.m. to 10 a.m., though the difference is trivial, and the peak hour is 4 to 5 a.m. On the other hand, the maximum 6-hour period for institutional births is from 11 p.m. to 5 a.m., with 28·3 per cent. of the deliveries.

TABLE VIII

ESTIMATED FREQUENCIES OF DELIVERY TIMES—ALL LIVE AND STILL BIRTHS, BIRMINGHAM, 1950, 1951

Time of Delivery	Domiciliary Births Per cent.	Institutional Births Per cent.	All Births Per cent.
12 Midnight	3·8	4·6	4·2
1 a.m.	4·4	4·4	4·4
2 a.m.	5·2	4·6	4·9
3 a.m.	5·3	5·3	5·3
4 a.m.	5·4	4·7	5·0
5 a.m.	4·6	4·4	4·5
6 a.m.	4·9	4·4	4·7
7 a.m.	4·9	4·4	4·6
8 a.m.	4·6	4·2	4·4
9 a.m.	3·7	4·0	3·9
10 a.m.	3·7	3·6	3·7
11 a.m.	4·0	3·9	3·9
12 Noon	3·6	4·1	3·8
1 p.m.	3·6	4·0	3·8
2 p.m.	3·5	3·9	3·7
3 p.m.	3·3	4·0	3·7
4 p.m.	3·8	4·0	3·9
5 p.m.	4·0	3·6	3·8
6 p.m.	3·8	3·8	3·8
7 p.m.	3·7	3·8	3·7
8 p.m.	3·7	3·3	3·5
9 p.m.	3·7	4·2	4·0
10 p.m.	3·7	4·2	4·0
11 p.m.	5·1	4·6	4·8
Total ..	100·0	100·0	100·0

The results of Table VIII can be compared with the two other sets of data previously mentioned for Lancashire and New York, the latter being available for 3-hourly periods only. It is not clear whether the Lancashire figures include stillbirths and the proportion of these is higher in the New York data, but the proportion of stillbirths is in any event too small to affect the broad picture. In general the Birmingham results agree fairly well with both New York and Lancashire, perhaps more closely with the latter. All three sources give a peak period between 3 and 6 a.m. The New York distribution shows the least difference between day and night, and the Lancashire figures the most, but in the latter case the maximum 12-hour period starts at 11 p.m.

The main point in which the Birmingham data differ from the other two is that both New York and Lancashire show a pronounced peak at about 10 a.m. This is found in New York in both live and still births, being particularly marked in the latter. One of the four sub-classes of Birmingham primigravidae show a pronounced peak at 10 a.m., but otherwise there is no trace of one. The primigravidae, as a whole, however, have a pronounced peak at 11 a.m. which probably corresponds to the Lancashire one (Fig. 11). This peak is visible in the graph of all selected cases (Fig. 10), though it has almost disappeared when all live and still births are taken together. The Lancashire and Birmingham patterns could be reconciled if there were a considerably higher proportion of first births in Lancashire. A high proportion of first births is indicative of low fertility, and the textile districts of Lancashire have long been known to be relatively very infertile (Charles and Moshinsky, 1938). The Registrar-General's Annual Statistical Review for 1949 gives the ratio of adjusted birth rates in Birmingham and the Administrative County of Lancashire as 1·05 : 0·97. From the adjusted rates for the separate portions of Health District No. 17, it appears that the total adjusted rate for the district as a whole would be a little below that for the Administrative County (Lancashire, 1952). It seems highly probable therefore that the Lancashire data contain a high proportion of first births. Unfortunately the same explanation cannot be invoked in the case of New York. It is highly unlikely that the proportion of first births at that period could be higher than in Birmingham, 1950–51. However, the figures quoted by Bradford Hill are clearly only a small fraction of all the births in New York State in 10 years, so that speculation would be profitless in the absence of fuller information. In any event, the spectacular fall in maternal mortality during recent years would cast doubt on the statistical comparability of an inquiry into conditions affecting childbirth 30 years ago.

If the suggested interpretation of the Lancashire-Birmingham difference is correct, we can suppose that in the future falling fertility would lead to a more even distribution of deliveries as between day and night. On the other hand, improvement in the health of the pregnant mother would be likely to yield a steeper curve by reducing the incidence of pathological conditions and shortening the duration of labour. To some extent the two anticipations cancel one another out, but we can perhaps envisage a continuing clear distinction between the two halves of the day, the maximum 12-hour period tending to be from midnight to noon rather than what would more properly be described as night-time. It is less easy to anticipate the effect, in Britain, of increasing or decreasing the proportion of institutional deliveries. The differences found are as likely to be due to selection of cases, in which event a change in practice would have no effect, as to attitudes to hospitalization.

(5) Diurnal Cycle in Single Days
Onset of Labour

At an earlier stage, we have noted that a single set of pooled data does not by itself provide adequate evidence of a diurnal cycle; but our analysis has indeed shown that the same diurnal pattern is manifest in pooled data of sub-groups referable to different calendar periods. We may submit the issue to a more exacting test by considering a succession of individual days. In the present study, there were available 66 continuous days in 1950 from August 1 to October 5. Unfortunately, the numbers in any one day were small, the average number of onsets per hour being only 1·4; and there is hence considerable scatter. Yet even such small numbers furnish corroboration for the view that there is a regular diurnal cycle. On 86 per cent. of the days, more than the expected number of labours started in the maximum 6-hour period, *i.e.* 11 p.m. to 5 a.m. A clearly defined peak appeared in 46 days, and of these peaks, 61 per cent. occurred in the same 6-hour period, the largest number being at 2 a.m. to 3 a.m.

Evidence supplied by such a consecutive series of days is amenable to scrutiny from another approach by recourse to the periodogram technique. We then consider the data as a series of 1,584 consecutive hours and seek for evidence of any periodicity. This forestalls any possible bias which might arise from pooling the data by days as has been done hitherto. Fig. 16 shows the result of a periodogram of oscillations at periods from 2 to 30 hours. The dotted lines indicate that some intervening values have not been determined. There is a minor period at 4 hours and multiples thereof. The main feature however is the 24-hour period standing out very sharply from neighbouring values. The examination of a consecutive series of hours does therefore substantiate, by a different method, evidence already presented for the existence of a diurnal cycle with respect to times of onset of labour.

(6) Summary

The author, no less than the reader, is well aware that this inquiry has raised many more questions than its outcome can answer. One reason for this is to be found in the limitation of hand processes. Owing to the complexity of the phenomena, more comprehensive and decisive conclusions would be justifiable only if based on more elaborate cross-classification, involving recourse to a much larger number of cases. Without mechanization, the labour involved in an inquiry planned on such a scale would be prohibitive. Unfortunately, few, if any, record systems (not excepting that initiated by the writer in Birmingham) allow for time of onset and of delivery as punched items. If it achieves no other result, the present investigation may provide

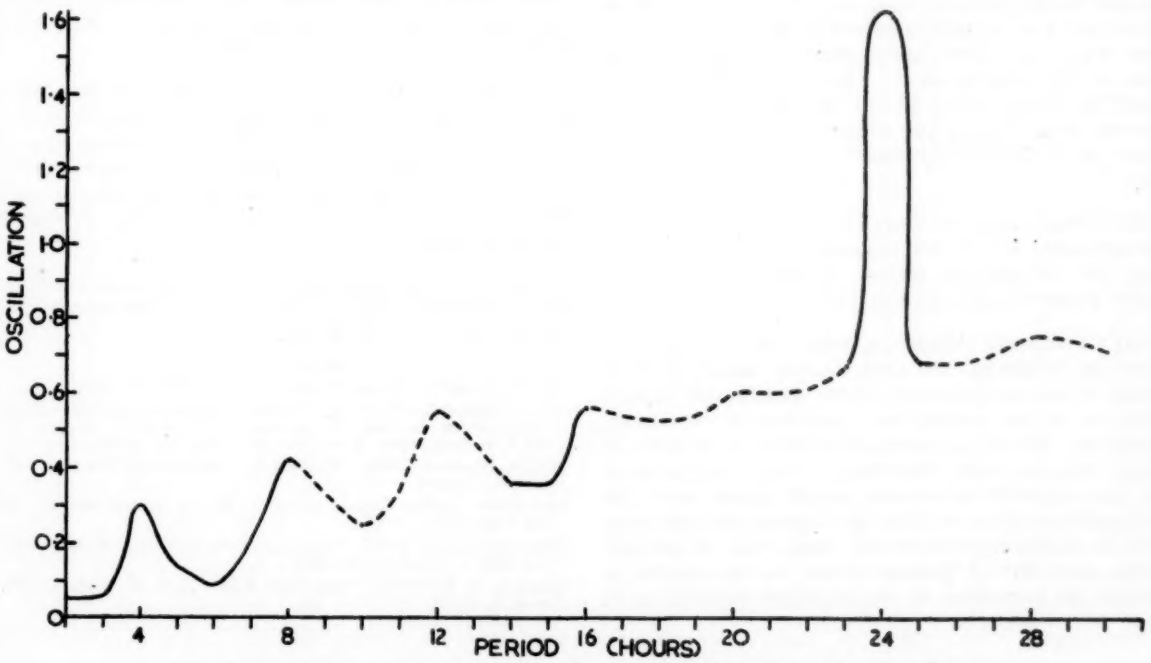

Fig. 16.—Periodogram of oscillation of times of onset of labour for periods of from 2 to 30 hours.

justification for planning a mechanized study of the subject on a much bigger scale.

From the methodological standpoint, some points raised in what has gone before are relevant to many inquiries involving time. With respect to diurnal rhythm, we have seen that it is necessary to draw a sharp distinction between solar time and that of the socially calibrated clock. To forestall misinterpretation arising from failure to make this distinction, the data of this inquiry were grouped seasonally to facilitate study of changes with respect both to intensity and wave-length of light as well as to changes referable to the social calendar. Considerations which prompted this type of breakdown are relevant to any statistical inquiries exploring seasonal differentials as an aetiological clue. The main points which emerge from the results can be summarized as follows:

(*i*) Times of onset of labour and times of delivery were tabulated for over 16,000 live and still births occurring in the City of Birmingham in 1951 and 1952. Detailed analysis was confined to a group of selected live births, from which were excluded:

(*a*) those exhibiting any one of a described number of conditions likely to affect materially the onset or course of labour;

(*b*) all induced onsets and/or deliveries.

(*ii*) The selected cases showed a striking diurnal rhythm with respect to time of onset, the maximum being at or near 2 a.m. to 3 a.m. and the minimum at about 1 p.m. to 2 p.m. If night is defined as the 12-hour period from 9 p.m. to 9 a.m., labour started at night in 62 per cent. of the selected cases. The diurnal rhythm was found in all the sub-classes of this group, though differences were seen in the steepness of the distribution and in the proportion of labours starting before the 2 a.m. peak.

(*iii*) Distributions of times of onset were steeper for primigravidae than for multigravidae and for domiciliary than for institutional births. Multigravidae show a higher proportion of onsets between 2 p.m. and 6 p.m.

(*iv*) Of seasonal differences, which are less clear cut than the foregoing, the data disclose relatively more onsets in the day-time in the winter months, and hence a flattening of the distributions referable to November, December, March, as compared with those referable to June, August, and September. Since distributions for cases referable to intervals equally spaced about the two equinoxes show no evidence of a peak-shift consonant with the change from Greenwich Mean Time to daylight-saving time (British Summer Time), we are entitled to exclude the activation of neurohumoral controls as an explanation of the diurnal periodicity. Our breakdown throws no direct light on the agencies contributory to the seasonal difference itself.

(*v*) The rejected cases and stillbirths showed much earlier onsets as well as a flatter distribution than the foregoing. The peak time of onset was 10 p.m. for rejected cases, and 9 p.m. for stillbirths.

(*vi*) As would be expected from the wide variation with respect to duration of labour, times of delivery are more evenly distributed throughout the 24 hours. For all selected cases, 55·6 per cent of the deliveries occurred in the 12-hour period 9 p.m. to 9 a.m., the peak delivery time being about 3 a.m.

(*vii*) The distribution of durations would result in an expected peak some hours later. It appears that durations are relatively more frequent both for primigravidae and for multigravidae when labour starts between 11 a.m. and 1 p.m., but are less so when it starts between 4 p.m. and 7 p.m. As a result of greater variation with respect to duration of labour, delivery times for primigravidae show less diurnal variation than do multigravidae, and are, in fact, approximately evenly distributed throughout the 24 hours. Rejected cases and stillbirths also show a more uniform distribution.

(*viii*) Delivery times of all live and still births show an excess of deliveries at night. The 12-hour period containing most deliveries is from 9 p.m. to 9 a.m. with 55 per cent. of births and the peak hour is 3 a.m. to 4 a.m. Results for Birmingham are compared with figures given for New York and Lancashire. The agreement between all three with respect to the proportion of births taking place at night is fairly close. Differences between Birmingham and Lancashire are explained by the greater frequency of first births in the latter district.

(*ix*) The results obtained suggest a tendency for normal labour to start more readily when the mother is at rest, if not actually asleep. Increasing severity of pathological conditions, as shown by the rejected cases and stillbirths, may be associated with a readier response to such emotional and nervous stimuli as are commonly believed to initiate labour.

The author acknowledges indebtedness to the Birmingham Maternity and Child Welfare Department for permitting access to the records.

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APPENDIX TABLE A

TIME OF ONSET OF LABOUR—SELECTED CASES, BIRMINGHAM, 1950, 1951

Time of Day	Date of Birth																All Births
	Domiciliary Births								Institutional Births								
	March 8 to April 4	June 8 to July 5	Aug. 1 to Sept. 7		Sept. 8 to Oct. 5	Nov. 1 to Dec. 7		Dec. 8 to Jan. 4	March 8 to April 4	June 8 to July 5	Aug. 1 to Sept. 7		Sept. 8 to Oct. 5	Nov. 1 to Dec. 7		Dec. 8 to Jan. 4	
			Primi-gravidae	Multi-gravidae		Primi-gravidae	Multi-gravidae				Primi-gravidae	Multi-gravidae		Primi-gravidae	Multi-gravidae		
12 Midnight	52	61	14	45	36	10	55	32	59	44	28	28	57	25	42	56	644
1 a.m.	73	77	28	64	66	11	64	57	55	71	45	31	63	30	34	42	811
2 a.m.	89	91	30	82	82	21	64	72	54	64	34	51	49	35	30	62	910
3 a.m.	88	70	23	52	64	8	55	47	55	56	38	35	51	34	27	51	754
4 a.m.	68	72	8	51	59	15	64	52	52	46	24	29	46	24	26	50	686
5 a.m.	47	32	10	34	41	9	40	39	26	39	18	29	44	17	17	33	475
6 a.m.	58	48	9	59	62	10	31	45	41	44	25	28	34	13	24	27	558
7 a.m.	47	51	11	39	38	4	37	34	30	38	15	28	34	15	26	35	482
8 a.m.	48	45	6	44	45	8	41	45	25	24	20	26	24	6	17	27	451
9 a.m.	53	32	9	36	29	6	32	31	29	24	21	20	23	22	21	36	424
10 a.m.	47	31	6	32	29	5	24	27	25	21	20	23	18	20	13	29	370
11 a.m.	34	32	8	23	26	4	28	23	29	22	20	16	19	15	19	28	346
12 Noon	21	25	5	22	27	5	21	22	36	33	16	18	29	14	21	16	331
1 p.m.	31	22	2	28	26	5	14	29	20	22	11	19	18	12	19	14	292
2 p.m.	40	36	8	32	43	7	39	39	47	27	14	19	26	22	23	27	449
3 p.m.	24	34	6	32	45	3	23	34	27	33	9	17	22	12	35	22	378
4 p.m.	37	39	3	34	30	6	32	25	37	25	16	20	34	11	24	27	400
5 p.m.	31	34	7	31	30	7	20	33	30	33	14	24	39	11	22	28	394
6 p.m.	47	43	8	40	37	11	46	32	34	35	12	25	33	14	24	40	481
7 p.m.	34	24	7	14	33	5	28	28	42	23	22	18	39	15	21	27	380
8 p.m.	36	50	6	30	43	7	38	20	41	23	13	18	32	23	17	31	428
9 p.m.	44	29	11	38	50	2	32	36	43	39	18	28	40	21	17	34	482
10 p.m.	78	70	4	56	40	8	42	50	55	53	33	28	43	27	23	41	651
11 p.m.	59	56	14	63	48	16	42	49	73	49	30	40	51	29	41	42	702
Total Births	1,186	1,104	243	981	1,029	193	912	901	965	888	516	618	868	467	583	825	12,279

APPENDIX TABLE B

TIME OF DELIVERY—SELECTED CASES, BIRMINGHAM, 1950, 1951

Time of Day	Date of Birth																All Births
	Domiciliary Births								Institutional Births								
	March 8 to April 7	June 8 to July 5	Aug. 1 to Sept. 7		Sept. 8 to Oct. 5	Nov. 1 to Dec. 7		Dec. 8 to Jan. 4	March 8 to April 4	June 8 to July 5	Aug. 1 to Sept. 7		Sept. 8 to Oct. 5	Nov. 1 to Dec. 7		Dec. 8 to Jan. 4	
			Primi-gravidae	Multi-gravidae		Primi-gravidae	Multi-gravidae				Primi-gravidae	Multi-gravidae		Primi-gravidae	Multi-gravidae		
12 Midnight	41	54	8	45	38	4	36	25	42	42	14	23	44	18	31	45	510
1 a.m.	50	47	10	46	45	3	39	42	54	36	19	26	42	15	20	40	534
2 a.m.	70	59	10	68	56	4	49	43	52	37	18	33	37	20	34	35	625
3 a.m.	62	74	7	53	46	11	60	41	65	50	19	46	39	20	39	52	684
4 a.m.	71	58	10	55	52	10	49	48	50	49	21	33	37	20	33	43	639
5 a.m.	54	50	16	39	46	11	47	45	44	55	14	24	45	20	22	44	576
6 a.m.	67	60	11	43	48	8	47	48	42	39	22	24	47	28	27	47	608
7 a.m.	55	62	16	49	42	12	41	45	42	40	23	26	39	27	25	45	589
8 a.m.	60	56	10	39	52	9	41	40	28	35	24	24	36	19	28	38	539
9 a.m.	46	33	8	41	41	9	39	31	36	39	24	25	41	13	21	34	481
10 a.m.	42	41	9	36	42	11	31	35	36	30	23	25	35	17	15	24	452
11 a.m.	45	42	7	33	42	14	33	47	32	30	29	24	30	25	27	40	500
12 Noon	34	45	13	39	38	6	29	30	39	44	22	28	34	17	19	29	466
1 p.m.	49	34	12	37	39	7	25	34	42	39	16	22	48	20	15	31	470
2 p.m.	44	40	10	27	35	8	33	36	33	26	28	23	35	17	25	23	443
3 p.m.	38	32	15	28	38	5	28	34	31	37	17	24	41	17	21	35	441
4 p.m.	46	34	9	40	41	9	28	36	39	25	29	21	33	21	23	25	459
5 p.m.	56	33	10	37	42	9	37	38	28	33	26	25	20	22	17	25	458
6 p.m.	43	47	10	29	39	3	36	40	41	30	22	18	32	15	24	25	454
7 p.m.	36	43	10	30	56	5	32	38	37	35	10	20	29	17	16	29	443
8 p.m.	44	48	7	40	41	6	24	30	31	31	17	18	27	15	20	22	421
9 p.m.	38	40	5	36	33	9	36	36	35	44	29	29	32	25	28	35	490
10 p.m.	41	48	7	33	41	8	40	30	39	27	25	25	34	22	25	30	475
11 p.m.	66	53	11	55	53	10	47	41	43	38	26	28	50	17	23	41	602
Total Births	1,198	1,133	241	978	1,046	191	907	913	961	891	517	614	887	467	578	837	12,359

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SOME OBSERVATIONS ON THE HEIGHTS AND WEIGHTS OF UNDERGRADUATES

WITH SPECIAL REFERENCE TO THE UNIVERSITY OF WALES

BY

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INTRODUCTION

It is standard practice, no matter what other anthropometric measurements may be taken, to record height and weight at routine medical examinations. There are a number of reasons for so doing. Height related to weight, or to some function of weight, at a given age may be used as an index of body build and physical constitution; gross deviation from standard norms may raise the suspicion of disease or nutritional deficiency; and periodic observations on the same individual afford a standard for assessing physical fitness and in some instances may be an aid to diagnosis. Considerations of individual health apart, however, perhaps the most interesting information is to be found in measurements derived from groups. Such measurements have, for example, been widely used as an index of health and development among children, and in a number of studies group differences in stature have been related to socio-economic background (Friend and Bransby, 1947; Bransby and others, 1946; Yudkin, 1944). Relationships between the stature of parents and their children have been studied by Pearson and Lee (1903), by Bowles (1932), and more recently by Durnin and Weir (1952). Still other investigations have demonstrated differences in stature between ethnic groups. Finally, a matter of some interest in the present context, a small but definite correlation has been established between stature and intelligence, and Parnell (1952) has drawn attention to relationships between various somatotypes and the academic performances of undergraduates at Oxford University.

Students form a convenient and relatively accessible group for anthropometric surveys and are often used as standards of comparison. The last survey carried out among students generally was that of Cathcart, Hughes, and Chalmers (1935). More recently, published information has been derived chiefly from Oxford and Cambridge, and is by no means necessarily representative of the student population of this country as a whole. Indeed, differences in group measurements between one university and another would not be unexpected. The distribution of students by socio-economic status is unlikely to be the same at the older universities as it is at provincial universities, and there may be differences among the provincial universities themselves in this regard. Moreover, Martin (1949) demonstrated differences in stature between young men from different regions of the country and these differences may be reflected in university groups, since provincial universities tend to draw their students predominantly from the local population.

Considerable changes in the size and composition of the undergraduate population of Great Britain have taken place in recent years. It would be of interest to establish information which could confidently be regarded as representative of the undergraduate population of the United Kingdom, and the observations which follow are presented as a contribution from the University of Wales. There are, in addition, points of particular interest in a study of a predominantly Welsh population. There is, for example, the possibility that ethnic factors might determine differences between Welsh students and others. Differences in physique between groups distinguished on socio-economic criteria, might, moreover, be accentuated in Wales as a result of adverse environmental experiences during the trade depression of the 1930s—a time when present-day students were passing through infancy or early childhood. On the other hand, during the recent war and in the post-war years, improved nutritional opportunities may have modified the consequences of earlier environmental stresses. Factors such as these have to be borne in mind and give added point to anthropometric studies at the present time.

Source of Data

The measurements were obtained at routine medical examinations conducted by the Student Health Service on new entrants to the University of Wales during the academic sessions 1949–50 and 1950–51, the figures for the 2 years having been combined. Attendance at these examinations is voluntary and the findings relate to approximately 77 per cent. of the intake during the 2 years. The fact that nothing is known about the measurements of some 23 per cent. of the entrants constitutes an admitted shortcoming in the data. It cannot be sufficiently emphasized therefore, that the conclusions must be regarded as tentative. Nevertheless, in the absence of more complete information, the results may not be entirely valueless, if only because they draw attention to matters worthy of further study and enquiry.

The measurements were taken as follows. For both men and women, height was measured in stockinged feet. Women were weighed semi-clothed, men were weighed with their trousers on. The stated weights are likely, therefore, to be some 1½–2 lb. heavier than the nude weights. In this respect the present information is similar to that obtained in other surveys.

Finally, it is necessary to point out that minor discrepancies between the totals for similar groups in the different analyses are due to the incompleteness of certain individual record cards.

Results

(1) *Students at the University of Wales, and the University of Cambridge, compared with the General Population.*—In Table I the mean heights and weights of male entrants to the University of Wales are compared with recent figures for freshmen at Cambridge (Bailey, 1951). The analysis made by Martin (1949) of the measurements of candidates for national service are also given. Two facts are noteworthy. The first is that Cambridge undergraduates were, on the average, 1·4 in. taller and some 8 lb. heavier than undergraduates at the University of Wales. The second is the marked superiority of both undergraduate groups when compared with the national servicemen. Cambridge freshmen were, on the average, 2 in. taller and some 17 lb. heavier than the recruits. The superiority of freshmen at the University of Wales, though of smaller degree, is, nevertheless, striking.

Martin's figures are the best available for young adults from the general population, but the national servicemen differed from the student groups in a number of particulars. Martin's analysis refers to men called up for military service in 1939, that is to say, before a national food policy came into operation, and the undergraduate groups were examined during the period 1948–51. The potential servicemen were, moreover, between 20 and 21 years of age The mean age of the Cambridge undergraduates was 21·0 years and that of the University of Wales undergraduates 20·5 years, but in both student groups the range was wider than in Martin's series.

It is unfortunate that figures representative of the contemporary young adult population are not readily available. Kemsley (1950), in a study of the heights and weights of industrial workers carried out by the Ministry of Food in 1943, gives mean values on a par with Martin's figures. The Ministry of Food survey, however, suffers from the drawback that it was conducted among civilians at a time when the fitter members of the population are likely to have been in the services. Consequently, physical selection may have influenced Kemsley's findings. It is, perhaps, less likely that physical selection of this kind would affect the findings among women, and in Table II (overleaf) women entrants to Cambridge University (Bailey, 1951) and to the University of Wales are compared with young women in two age groups taken from the Ministry of Food survey.

The findings among the women are similar to those among the men. Women at Cambridge were, on the average, an inch taller and some 6 lb. heavier than women at the University of Wales. Both undergraduate groups were markedly superior to the groups from the general population.

TABLE I

MALE UNIVERSITY ENTRANTS AND NATIONAL SERVICE RECRUITS: MEAN HEIGHTS AND WEIGHTS

Group	Date	Height (in.)			Weight (lb.)		
		No. of Observations	Mean ± S.E.	S.D.	No. of Observations	Mean ± S.E.	S.D.
Cambridge Freshmen	1948–50	3,100	69·91 ± 0·05	2·55	3,100	153·10 ± 0·29	16·29
University of Wales Freshmen ..	1949–51	1,532	68·5 ± 0·06	2·4	1,531	145·0 ± 0·45	17·2
National Service Recruits ..	1939	91,163	67·5 ± 0·009	2·6	91,084	135·7 ± 0·055	16·54

TABLE II

FEMALE UNIVERSITY ENTRANTS AND INDUSTRIAL WORKERS: MEAN HEIGHTS AND WEIGHTS

Group	Date	Mean Age (yrs)	Height (in.)			Weight (lb.)		
			No. of Observations	Mean ± S.E.	S.D.	No. of Observations	Mean ± S.E.	S.D.
University of Cambridge ..	1948–50	19·3	271	64·98 ± 0·15	2·50	271	133·21 ± 1·09	17·87
University of Wales..	1949–51	19·6	835	63·9 ± 0·08	2·4	834	127·6 ± 0·59	17·0
Industrial Workers ..	1943	19·5	1,376	62·26 n.s.	2·34	1,376	115·7 n.s.	15·21
		20·5	1,284	62·42 n.s.	2·31	1,284	118·0 n.s.	16·80

It must be borne in mind that the measurements at the universities were carried out among volunteers (Cambridge—75 per cent. of intake; University of Wales—77 per cent. of intake). The difficulty of obtaining information about the physique of young adults from the general population with which students could confidently be compared has already been mentioned. The evidence strongly suggests, however, that, at least in so far as mean heights and weights are concerned, students are considerably superior to similar age groups drawn from the general population. It would, perhaps, be surprising were this not so.

(2) *Regional Differences within the University of Wales.*—The possibility that variations in physical measurements might occur among students coming from different regions of Great Britain was next investigated. Entrants to the University of Wales were divided into three groups as follows:

(*a*) those whose homes were in Wales,
(*b*) those whose homes were in other parts of the British Isles,
(*c*) those from the Dominions, Colonies, and foreign countries, including students of foreign extraction resident in the United Kingdom only since 1945.

The overseas group was small and because of its heterogeneous character was not treated separately in the present analysis. A comparison between the two other residential groups is more legitimate and of greater interest (see Table III).

Among the men, students resident in Wales were, on the average, nearly an inch shorter and some 5 lb. lighter than students residing elsewhere in the British Isles. Among the women there was a similar difference in height and the residents outside Wales had an advantage of 8 lb. in weight when compared with women residing within the principality.

It might be argued that migration of families to and from Wales would affect the findings, but the effects of migration, if any, were small. Students whose homes were in Wales had generally lived there all their lives, and the same impression was gained from those whose homes were in England. It seemed likely, however, that differences in the age structure of the two residential groups might have contributed to the observed differences in mean heights and weights, and this possibility will now be examined.

(3) *Effects of Age.*—Bailey (1951) showed that, among Cambridge freshmen, weight varied appreciably according to age at entrance. Height, on the other hand, was not materially affected. The findings at the University of Wales were similar,

TABLE III

MEAN HEIGHTS AND WEIGHTS OF STUDENTS OF THE UNIVERSITY OF WALES BY PLACE OF RESIDENCE

Sex	Place of Residence	No. of Observations	Height (in.)		Weight (lb.)	
			Mean ± S.E.	S.D.	Mean ± S.E.	S.D.
Males	In Wales	1,236	68·4 ± 0·07	2·5	144·3 ± 0·51	17·3
	Elsewhere in British Isles	243	69·3 ± 0·14	2·2	149·1 ± 1·01	15·7
Females	In Wales	703	63·8 ± 0·10	2·3	126·7 ± 0·64	17·0
	Elsewhere in British Isles	111	64·6 ± 0·19	2·0	132·6 ± 1·67	17·8

TABLE IV

MEAN WEIGHTS BY AGE RELATED TO PLACE OF RESIDENCE

Sex	Age at Entry (yrs)	Resident in Wales			Resident elsewhere in the British Isles			All Students (including those from Overseas)		
		No. of Observations	Mean Weight (lb.) ± Standard Error	Standard Deviations	No. of Observations	Mean Weight (lb.) ± Standard Error	Standard Deviations	No. of Observations	Mean Weight (lb.) ± Standard Error	Standard Deviations
Males	18 and under	470	141·9 ± 0·73	15·9	52	147·6 ± 1·89	13·6	528	142·4 ± 0·71	16·4
	19–	252	144·4 ± 1·14	17·6	45	149·4 ± 2·28	15·3	300	145·2 ± 1·00	17·3
	20–	187	144·6 ± 1·30	17·7	37	148·6 ± 2·02	12·3	227	145·2 ± 1·12	16·9
	21–	161	147·5 ± 1·35	17·1	36	150·9 ± 2·55	15·3	202	147·7 ± 1·20	17·1
	22–	47	145·6 ± 2·28	15·7	23	148·1 ± 3·96	19·0	70	147·7 ± 1·96	16·4
	23 and over	119	148·7 ± 1·75	19·1	50	153·0 ± 2·55	18·0	205	148·0 ± 1·35	19·4
Females	18 and under	423	127·1 ± 0·86	17·8	45	131·0 ± 2·40	16·1	473	127·6 ± 0·81	17·6
	19–	174	127·0 ± 1·13	14·9	28	132·2 ± 3·27	17·3	207	128·2 ± 1·14	16·4
	20–	54	123·3 ± 2·12	15·6	15	136·3 ± 5·32	20·6	72	127·5 ± 2·06	17·5
	21–	16	128·1 ± 4·02	16·1	12	131·7 ± 6·38	22·1	29	128·8 ± 3·56	19·2
	22 and over	36	119·7 ± 2·65	15·9	11	135·9 ± 4·85	16·1	53	125·6 ± 2·39	17·4

and for this reason, the age-weight relationship only is considered in the present analysis.

The results are shown in Table IV, in which a comparison between age groups in the two areas of residence (Wales and "elsewhere in the British Isles") is also given. Two points emerge from consideration of Table IV. The first is the distinct advantage of students from outside Wales in each age group and in both sexes. This disposes of the possibility that differences in age distribution accounted for the disparities in physique between the two residential groups noted in Table III. The second point is that, in contrast with the experience for men, no consistent relationship between age and weight was demonstrated among the women.

A significant positive correlation between weight and age is demonstrated for males in Table IVA. There is no significant correlation between weight and age for females. The difference between the correlation coefficients in the two male residential groups is not significant ($t = 1{\cdot}5$; $0{\cdot}2 > p > 0{\cdot}1$).

The difference between the sexes is noteworthy. Subsidiary information obtained at Student Health examinations demonstrated a similar trend in age-weight relationship (see Table V). A number of students initially examined during the session 1949–50 were re-examined during the session 1951–52, on the average some 2 years later. This group consisted of 474 men and 259 women who had survived examination hurdles and other hazards of university life and were available for and desirous of a second

TABLE IVA

CORRELATION COEFFICIENTS AND REGRESSION EQUATIONS OF WEIGHT ON AGE

Sex	Place of Residence	Correlation Coefficients Age/Weight	Regression Equations Weight/Age
Males	In Wales ..	+0·126 ± 0·03	Wt. = 0·902 Age + 126·1
	Elsewhere in British Isles..	+0·226 ± 0·06	Wt. = 1·202 Age + 123·6
Females	In Wales ..	−0·063 ± 0·04	
	Elsewhere in British Isles..	+0·088 ± 0·10	

TABLE V

WEIGHT LOSS OR GAIN 2 YEARS AFTER INITIAL EXAMINATION (ALL STUDENTS)

Weight (lb.)		Males		Females.	
		No.	Per cent.	No.	Per cent
Gain	15 and over ..	23	4·9	8	3·1
	11–14	44	9·3	9	3·5
	7–10	76	16·0	24	9·3
	3– 6	123	25·9	30	11·6
Stationary		148	31·2	106	40·9
Loss	3– 6	37	7·8	29	11·2
	7–10	20	4·2	35	13·5
	11–14	3	0·6	13	5·0
	15 and over ..	—	—	5	1·9
Total		474	99·9	259	100·0

medical examination. Results from a group of this nature must clearly be interpreted with caution. At all events they indicate that the difference between the sexes in age-weight relationship noted at initial examinations was paralleled at the second examination in those students upon whom it was possible to carry out a longitudinal study. During the 2 years between the examinations most of the men had gained weight. Relatively few women experienced a gain in weight and there was no clear group tendency for them to do so.

$$(\chi^2 = 77;\ n' = 6;\ p < 0{\cdot}01)$$

It may be that this finding represents a biological difference between the sexes, maximum increase in weight among girls taking place around puberty and among men continuing to increase beyond late adolescence. The extent to which the findings in Table V are influenced by voluntary weight reduction among women students can only be surmised.

(4) *Effects of Socio-Economic Status.*—Entrants to the University of Wales were classified by reference to parental occupation according to the Registrar-General's five social classes (Table VI). Somewhat surprisingly there was almost no difference either in mean heights or in mean weights among males in the different social classes. A small social gradient is suggested for mean heights and weights among female students, and a separate analysis showed that differences between Social Classes I and II combined and IV and V combined were unlikely to have occurred through chance. An examination of the ages of men and women in the different social classes showed little difference in age distribution.

The absence of a social gradient among the men was an unexpected finding, the more so, perhaps, in view of findings at Cambridge (Bailey, 1951). Using the type of school attended as a socio-economic criterion, Bailey demonstrated a gradient in both height and weight. The type of school attended by students at the University of Wales could not be used as an index of socio-economic status because of the small number of public school men entering the university during the two sessions. Although no straightforward comparison can be made between the two surveys, the contrast between the results at the two universities is noteworthy.

Here it should be stated, however, that although conventional social class analysis failed to show differences between group measurements at the University of Wales, it was possible to demonstrate differences between groups distinguished on other criteria. Thus the sons of miners were compared with the sons of farmers; both groups were well represented at the university, and the comparison was of local interest because both farming and mining communities figure largely in the life of Wales. Moreover, there is likely to have been a marked contrast in the nutrition of the two groups in early childhood, since many of the present-day students were born during the years of depression in the Welsh coal industry.

TABLE VI

MEAN HEIGHTS AND WEIGHTS BY SOCIAL CLASS OF PARENTS
(Dominions, Colonial, and Overseas Students Excluded)

Sex	Social Class	Height (in.)			Weight (lb.)		
		No. in Group	Mean ± S.E.	S.D.	No. in Group	Mean ± S.E.	S.D.
Males	I	159	68·8 ± 0·18	2·25	159	145·4 ± 1·32	16·61
	II	557	68·6 ± 0·10	2·35	556	145·9 ± 0·68	16·02
	III	557	68·6 ± 0·11	2·51	557	144·7 ± 0·78	18·45
	IV	144	68·2 ± 0·21	2·49	144	143·7 ± 1·39	16·70
	V	57	68·2 ± 0·31	2·36	57	146·2 ± 2·11	15·95
	Total	1,474			1,473		
Females	I	99	64·0 ± 0·22	2·24	99	128·1 ± 1·35	16·59
	II	358	63·7 ± 0·13	2·47	358	128·0 ± 0·90	17·10
	III	271	63·6 ± 0·15	2·15	271	126·5 ± 0·95	15·71
	IV	57	63·0 ± 0·32	2·42	57	123·4 ± 1·30	16·38
	V	24	63·1 ± 0·44	2·15	24	126·2 ± 2·96	14·48
	Total	809			809		

The results (Table VII) showed that farmers' sons were, on the average, just over an inch taller and some 5 lb. heavier than the sons of miners, both differences being significant at the conventional 5 per cent. level.

TABLE VII

MEAN HEIGHTS AND WEIGHTS OF FARMERS' AND MINERS' SONS

Father's Occupation	No. of Observations	Height (in.)		Weight (lb.)	
		Mean ± S.E.	S.D.	Mean ± S.E.	S.D.
Miner ..	156	68·2 ± 0·21	2·6	143·9 ± 1·42	18·0
Farmer	81	69·4 ± 0·30	2·7	149·0 ± 1·63	14·7

The general tendency of rural dwellers to have a physique superior to that of town dwellers is well known. However, when the measurements of all students were compared according to whether they lived in urban or in rural areas, no difference could be demonstrated. The explanation of the difference between miners' and farmers' sons is, in fact, not simple, and has been referred to here mainly to show that, despite the absence of an overall social gradient, at least one group difference existed.

A number of possible explanations for the absence of an overall social gradient for heights and weights come to mind. For example, the sample of students may be unrepresentative. Voluntary attendance for medical examinations may introduce a bias towards equalizing the average measurements in the social classes. It is conceivable, for instance, that two extreme groups—with superior or inferior physique—are least likely to be attracted to a medical examination, and that the former may come predominantly from wealthier families and the latter from the less well-to-do. Another explanation which must also be considered, is that in contrast with Cambridge undergraduates, the majority of students at the University of Wales were educated at secondary schools. Boys and girls from well-to-do families in Wales sometimes go to English public schools and proceed to English universities, and if the majority of such students are from Social Class I, those of that class who go to the University of Wales may be unrepresentative in respect of physique. If this were indeed an important factor, it is possible that there is more variability in physical measurements *within* Social Class I among students in Wales than there is *between* the social classes as demonstrated in Table VI.

A further point is the physique of the general population. Published surveys are based mainly on data obtained before or during the last war. Recent social advances may have caused a levelling-off of physique among young people of different socio-economic backgrounds. If this is so, the findings at the University of Wales would be no more than a reflection of a process that has been generally operative.

It is impossible to reach any final conclusion when so many factors may have been concerned and when so much is unknown. Basing observation on available figures, the most outstanding impression is that variations between students of different socio-economic status are small in comparison with the marked superiority of all student groups over the general population. This suggests, as others have pointed out, that young adults who are destined for a university career, and whose intellectual endowment is presumably above average, are also, irrespective of socio-economic status, of superior physique. The relative contributions of nature and nurture to this physical advantage have been discussed by Parnell (1952). It is now proposed to examine certain aspects of this problem with particular reference to undergraduates at the University of Wales.

(5) *Influence of Nationality: "Natives" and "Migrants".*—It has already been shown (Tables III and IV) that students at the University of Wales classed as living "Elsewhere in the British Isles" were, on the average, taller and heavier than residents in Wales, and that this advantage was independent of differences in age distribution. The mean measurements of the "migrant" group (i.e. those from outside Wales) closely resemble those of Cambridge students from "other" schools. It may be assumed that the majority of Cambridge students in this group were educated at English secondary schools and would be comparable—at least in so far as a common educational background is concerned. It is not surprising, therefore, that the mean heights and weights of these two groups are almost identical (Table VIII).

TABLE VIII

MEAN HEIGHTS AND WEIGHTS OF FRESHMEN AT THE UNIVERSITY OF WALES, RESIDENT OUTSIDE WALES, COMPARED WITH CAMBRIDGE FRESHMEN OF SIMILAR EDUCATIONAL BACKGROUND

University	No. of Observations	Height (in.) Mean ± S.E.	Weight (lb.) Mean ± S.E.
Wales ..	243	69·3 ± 0·14	149·1 ± 1·01
Cambridge	482	69·4 ± 0·1	150·9 ± 0·7

The superiority of the students with a background of secondary education in England over those who had had a similar education in Wales might be due

TABLE IX

DISTRIBUTION OF MEN STUDENTS BY SOCIAL CLASS*, SURNAME†, AND PLACE OF RESIDENCE

Social Class	Resident in Wales						Resident elsewhere in the British Isles						Grand Total	
	Surnames				Total		Surnames				Total			
	"Welsh"		"English"				"Welsh"		"English"					
	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.
I and II	396	47·8	167	41·4	563	45·7	44	62·9	109	63·0	153	63·0	716	48·6
III	300	36·2	184	45·7	484	39·3	21	30·0	52	30·0	73	30·0	557	37·8
IV and V ..	132	16·0	52	12·9	184	15·0	5	7·1	12	7·0	17	7·0	201	13·6
Totals	828	100·0	403	99·9	1,231	100·0	70	100·0	173	100·0	243	100·0	1,474	100·0

* Because of the small numbers Social Classes I and II and also IV and V have been combined.
† The use of the surname as an index of racial origin was suggested by the work of Fraser Roberts (1948) on the distribution of blood groups.

to regional differences in physique between English and Welsh people, though this would not be an altogether safe assumption. Possible explanations are:

(*a*) selection at university entrance,
(*b*) differences in social structure between the two groups,
(*c*) physical differences in the populations from which the students were drawn.

Under (*a*) such factors as the actual selection of candidates for entrance, circumstances which determine choice of university, and the availability of special courses (e.g. Forestry, Mining) might be operative and might favour certain physical types. The possible influence of factors of this kind has been referred to in connexion with the social class analysis above. An analysis by social class for the two residential groups is shown in Table IX. (For the sake of convenience certain "surname" subgroups are also distinguished in the Table and will be referred to later.)

The distribution of social classes between the two residential groups is significantly different (cols. 3 and 6—Table IX). Students from the lower social classes are less likely to reach the University of Wales if they live outside Wales than if they live within the principality. Dissimilarity of social background may therefore have contributed to the differences in heights and weights.

It is impossible to assess the extent to which (*a*) and (*b*) have influenced group measurements, but the fact that they may have done so should not be overlooked. The possibility that physical differences between the two populations might account for the observed differences in physique calls for more extended comment. It is often said that the Welsh tend to be of smaller physique than the English. It might consequently be argued that racial factors were responsible for the differences in physique between English and Welsh students. Upon this point it is possible to throw a little light.

Students from the two residential areas were subdivided according to nationality of surname‡, four subgroups being distinguished:

(*i*) residents in Wales with "Welsh" surnames,
(*ii*) residents in Wales with "English" surnames,
(*iii*) residents in England with "Welsh" surnames,
(*iv*) residents in England with "English" surnames.

It is suggested that, if race were more important than environment in determining physique, the average measurements of students with "Welsh" surnames would tend to be similar whether they lived in Wales or elsewhere in the British Isles, and that the same would be true of students with "English" surnames. The results (Table X) show a much greater similarity between subgroups by area of residence than by nationality of surname.

‡ The analysis was limited to males.

TABLE X

MEAN HEIGHTS AND WEIGHTS BY SURNAME AND PLACE OF RESIDENCE

Place of Residence	Surname	No. of Observations	Height (in.)		Weight (lb.)	
			Mean ± S.E.	S.D.	Mean ± S.E.	S.D.
Outside Wales	"English"	173	69·3 ± 0·13	2·3	150·2 ± 1·22	16·1
	"Welsh"	70	69·2 ± 0·21	1·8	149·4 ± 1·89	15·9
In Wales	"English"	403	68·6 ± 0·12	2·4	145·2 ± 0·79	15·8
	"Welsh"	828	68·2 ± 0·08	2·4	143·8 ± 0·63	18·0

TABLE XI
HEIGHTS AND WEIGHTS OF MALE STUDENTS FROM 1899–1951

Group	Source of Data		No. of Observations	Height (in.)		Weight (lb.)	
	Author	Date		Mean ± S.E.	S.D.	Mean ± S.E.	S.D.
Cambridge Undergraduates	Pearson*	1900	1,000	68·86 ± 0·08	2·52	152·78 ± 0·52	16·55
Oxford Students	Schuster†	1911	959	69·49 ± 0·08	2·60	151·94 ± 0·53	16·37
Students from certain British Universities	Cathcart, Hughes, and Chalmers	1935	1,735	68·9 *n.s.*		138·5 *n.s.*	
Cambridge Freshmen	Bailey	1951	3,100	69·91 ± 0·05	2·55	153·10 ± 0·29	16·29
University of Wales Freshmen	Present Study	1949–51	1,532	68·5 ± 0·06	2·4		
		1949–51	1,531			145·0 ± 0·45	16·5

* See also Powys (1901).

† Parnell (1952) states that there have been negligible changes in the heights and weights of Oxford undergraduates during the past 40 years.

The differences between the figures for students by areas of residence are significant at the conventional level. The differences between surname subgroups within each area of residence are no greater than could have occurred by chance.

Before attempting an interpretation of this finding, one further point must be considered. When the surname subgroups were examined for social distribution, there was a significant difference between the subgroups resident in Wales, though the groups from outside Wales were similar (see Table IX). Social Classes I and II were relatively less well represented in the English surname subgroup, and Social Class III was more heavily represented. One of several possible explanations is that students in Social Classes I and II with "English" surnames, resident in Wales, have a greater tendency to enter English universities. If this were so, students in this subgroup might be less representative than those with "Welsh" surnames. The possible effect on group physical measurements of "missing" students from the top social classes has already been discussed. Taking the findings at their face value, all that can be said with certainty, is that, despite a somewhat less favourable social distribution, the physical measurements of students with "English" surnames resident in Wales do not differ significantly from those with "Welsh" surnames resident in Wales.

It must be admitted that the use of surname is a crude index of racial origin. Nevertheless, the analysis in Table X suggests that environmental rather than racial factors accounted for the observed differences in physique between students grouped by area of residence.

(6) *Heights and Weights of Students during the Past 50 Years.*—Finally, it is not without interest to compare measurements obtained from undergraduate groups during the past 50 years. The figures (males only) are shown in Table XI.

Except in the case of the mean height of Cambridge students, which has increased by about one inch, there appears to have been little change in the mean height and weight of undergraduates at the older universities since the turn of the century.

Students in the survey of Cathcart and others (1935) were, on the average, some 13–14 lb. lighter than students at Oxford and Cambridge 40 to 50 years ago. The method by which Cathcart's students were selected for measurement is not clear. If, despite the inclusion of some Oxford students, the survey may be taken as more or less representative of provincial universities in 1935, and if it can be assumed that mean weights of students at provincial universities to-day would be at least as high as those obtained at the University of Wales, it would appear that an increase of about 7 lb. in the mean weights of students at provincial universities had occurred during the past 15 years or so.

During recent years, social and economic barriers to university education have been progressively relaxed, and the consequent broadening in social structure may account for the absence of a gain in the mean weights of students at the older universities. On the other hand, the comparison between Cathcart's findings and our own lend support to the view that any tendency that changes in social structure might have had in reducing mean weights has been more than counterbalanced by the improved nutritional opportunities of the population at large.

SUMMARY

(1) The superior stature and body weight of student groups compared with young men and women in the general population is demonstrated.

(2) Among undergraduates at the University of Wales, students residing outside Wales were superior in height and weight to those who lived in Wales.

(3) A small but significant positive correlation between weight and age was found among men at the University of Wales. No correlation between weight and age was found among women.

(4) Among male undergraduates at the University of Wales, no significant differences were found between mean heights and weights when students were grouped according to parental social class. Among women students there was a small but significant difference between the mean heights and weights in Social Classes I and II combined and those in Social Classes IV and V combined. Possible reasons for the absence of social class differences are disucssed.

(5) Area of residence appeared to be of greater importance than nationality (using surname as a criterion) in determining differences between the mean heights and weights of residential groups.

(6) The trend of mean heights and weights among male students at a number of universities during the past 50 years is discussed.

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* Powys is given as author. Footnote by Pearson states: "The following data were freely placed at my disposal by Powys. I have added little to his own notes."

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EFFECT OF UPPER DECK TEMPERATURE ON THE HEALTH OF MEN IN SHIPS OF THE ROYAL NAVY

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There have been several attempts in recent years to relate the incidence of sickness in the Royal Navy to variations of the thermal environment of ships' companies. During the second world war the incidence of the common causes of ill health, as revealed by attendances at the sick bay, was shown to be nearly twice as great in the ships of the Eastern and British Pacific Fleets as it was in shore establishments, where the mean air temperature was usually about 7°F. lower than the temperature between decks; this difference was due largely to an increase in the incidence of skin disease (Ellis, 1947, 1948). Time lost due to sickness was doubled or trebled when ships joined the Eastern Fleet from the Mediterranean or Home Fleets.

When the war ended, relaxation of security precautions concerning the movement of warships made it possible for such information to be included in the monthly returns of sickness to the Admiralty. These returns revealed that during the first year after the war the relative sickness incidence was more than doubled in tropical waters as contrasted with northern temperate waters, and diseases of the skin were increased by three to four times (Roberts, 1948).

Recent work suggests that for different classes of ships it may be possible to predict the mean mess-deck temperature with reasonable accuracy provided the mean upper deck temperature is known (Gray and Smith, 1952). In this event it may be possible to relate sickness to the average thermal environment between decks more accurately than has been possible hitherto. In 1948 it was requested that the mean upper deck temperature at noon should be included with each monthly return. The results of the analysis of the returns including this information for the year October 1, 1948, to September 30, 1949, are described below.

Methods

Medical officers in charge of ships reported the numbers on the attending lists and sick lists at midnight each Wednesday and also the numbers who had been sent to hospital during the previous week. The total number of cases on the sick and attending lists was subdivided into (*a*) respiratory infections, (*b*) dysentery and diarrhoea, (*c*) skin disorders, (*d*) all other diseases, and (*e*) injuries and accidents. The average weekly air temperature on the upper deck at noon was included with each weekly report together with information on the whereabouts of the ship. These particulars were supplied in accordance with the detailed instructions reproduced below:

(2) The return is to be rendered only by ships carrying a medical officer; medical officers in parent ships are to make returns for their parent ship only and not for personnel in tenders.

(3) The fixed time each week to which the count will refer is at 23.59 on each Wednesday. The returns are to be made each calendar month and will include four or five weekly counts, depending upon how many Wednesdays there are in the particular calendar month. The figures for the last Wednesday of the previous calendar month are also to be included, so that the rate for the first weekly period can be worked out. Nil returns are to be made. Immediately after the last count of the calendar month, one copy of the return is to be forwarded to the Medical Director General, Admiralty, and one copy to the Fleet Medical Officer.

(4) The average complement is to be given for each week, and in calculating complement and number of cases, both officers and ratings are to be included together.

(5) The count of Sick List cases (with Excused Duty List cases) is to include all those who are excused duty as at 23.59 on the Wednesday in question.

(6) For the purposes of this return a patient is to be regarded as being on the Attending List when he attends at the sick bay and is instructed to report again within a period not exceeding a fortnight. Single visits with no instruction to return are not to be included. If the patient is told that he need not attend again, or not within a period of a fortnight, he is no longer to be shown in the return. No distinction is to be made between those on light duty and those on full duty.

(7) The few broad disease groups chosen are designed particularly for investigating habitability, and the effect of differences in climate. "Upper Respiratory Infections" should include infections of the nose, sinuses, naso-pharynx, larynx, and trachea, including influenza, colds, sore throats, and Vincent's infection; it should *not* include diseases of the bronchi and lungs. "Diseases of the Skin" should include boils, otitis externa, tropical ulcers, and

mycotic infections. Scabies and pediculosis should be included with "All Other Diseases" and *not* under "Diseases of the Skin".

As in the certification of deaths, serious disease following a very trivial injury should be classified as disease and not as injury, *e.g.* septicaemia following a scratch, and all tropical ulcers. Illness due to noxious agents, bites or stings, attempted suicide, or extremes of physical conditions, *e.g.* heat stroke or frostbite, should be classified as injury.

(8) There must be no duplication of cases, *i.e.* one and the same man can only appear once in the weekly count. If he is suffering from more than one illness and could be included under more than one disease heading, the medical officer is to decide on a primary diagnosis and the man should be so classified. THE SICK LIST TAKES PRECEDENCE OVER THE ATTENDING LIST. For example, if a man "returned" as on the Attending List at a given Wednesday midnight owing to a skin condition, subsequently develops a cold and is on the Sick List at midnight the following Wednesday, he should be shown in the second Wednesday's count under "Sick List—Upper Respiratory Infections". If by the third Wednesday he has been discharged from the Sick List but remains on the Attending List owing to his skin condition he will once again appear under "Attending List—Skin Diseases" in the count for the third Wednesday. If a man is on the Sick or Attending List for more than one disease, the medical officer should decide on the primary diagnosis.

(9) Cases of venereal disease are *not* to be included in the return.

(10) In view of the possible differences of procedures regarding discharge from the ships' books of those sent to hospital, it is not possible to make a simple count of men in hospital as at 23.59 each Wednesday. Instead, the figure (unlike those of the Sick and Attending Lists) will refer to the number of cases discharged to hospital during the week ending at 23.59 on Wednesday. Hospital cases will be shown in total only.

(11) The position and movements of the ship during the period of the return are to be included in the space provided. It will be appreciated that what is required is a full resumé with dates. What is important is whether the ship is (*a*) in port and, if so, in what ports; (*b*) at sea, and in approximately what waters.

Periods in port can easily be recorded with names and dates. If the ship is proceeding to sea daily for exercises it will be sufficient to mention that fact in all brevity. Voyages other than those direct from port to port will require more detailed particulars.

(12) In the space for remarks should be included information concerning any special circumstances which might have had an effect on the figures, *e.g.* epidemics, serious accidents, prevalent diseases ashore, leave, etc.

Thus the percentages of men on the Sick and Attending Lists were based on weekly census counts taken at midnight on each Wednesday. A given week runs from Wednesday midnight to Wednesday midnight and the figures for that week are estimated by averaging the figures at the beginning and the end. This does not provide information on case incidence or on the duration of individual sicknesses; the measure which is obtained is simply the percentage of the ship's company who are sick. This is a constantly fluctuating figure, but experience has shown, for example in the short term sickness returns of the United States Army (1952), that the mean of the census counts at the beginning and end of each week provides sufficiently accurate information for all practical purposes.

The admission of men to hospital cannot, for a variety of reasons, be dealt with by a cenus method. Hospital admissions are included to complete the record, though the numbers are normally small.

The most impressive effects of climatic change are found in the size of the attending lists. It is therefore important to note that the instructions relating to the returns on which this report and the earlier one by Roberts are based state that a man should only be shown as on the Attending List if he has been instructed to return again for treatment within a fortnight. Thus single attendances for conditions of trivial importance, and many skin conditions aggravated by warm climates fall into this category, would not be shown and would not contribute to the sickness incidence reported below.

The units employed in the construction of the Tables and Figures are the average monthly percentages; the months being periods of four or five weeks and not calendar months.

RESULTS

During the year under consideration, sickness returns which were suitable for analysis were received from 77 ships, and as each ship rendered on the average just over eight monthly returns there were 282,000 man-months available for analysis; rather less than the 1,600,000 man-weeks which were available to Roberts (1948) for the first year after the war ended.

The number of man-months available for examination in relation to the prevailing upper deck temperatures is slightly less than the number available for examination in relation to the station on which ships were at the time, because in some instances, although the station was noted on the return, the temperatures were either not included or were obviously faulty.

SICKNESS INCIDENCE AND UPPER DECK TEMPERATURE.—The data were analysed to show the effects of variations in the mean upper deck temperature on the percentages in the attending and sick lists, and on the numbers of men sent to hospital in the previous week. These relationships for all classes of ship are shown in Table I, and illustrated in Fig. 1. There was very little change in the sick list incidence whatever the upper deck temperature, but the attending list increased gradually as the average weekly noon upper deck temperature rose. When the temperature rose above 80°F. there was a steeper rise in the attending list, and when the mean upper deck temperature exceeded 90°F. the increase was very striking.

Ships do not spend very much time in parts of the world where the mean noon temperature exceeds 90°F. The average number of weeks during which

TABLE I

MEAN WEEKLY SICKNESS INCIDENCE (PER CENT.) FOR ALL SHIPS IN RELATION TO VARIATIONS IN MEAN WEEKLY NOON UPPER DECK TEMPERATURE

Dry Bulb Temperature (°F.)		30–34·9	35–39·9	40–44·9	45–49·9	50–54·9	55–59·9	60–64·9	65–69·9	70–74·9	75–79·9	80–84·9	85–89·9	90–94·9	95–99·9	Mean
No. of Ship-months (Total 641)		2	2	10	49	67	94	59	82	68	63	88	50	6	1	
Attending	Upper respiratory infections ..	0·55	0·61	0·53	0·84	0·45	0·45	0·53	0·44	0·44	0·30	0·50	0·46	0·83	0·07	0·50
	Dysenteries and diarrhoea ..	0·11	0·04	0·05	0·07	0·08	0·08	0·08	0·08	0·12	0·23	0·15	0·11	0·61	0·00	0·11
	Skin diseases ..	0·95	1·21	0·75	0·82	0·94	1·29	1·40	1·59	1·42	1·81	2·57	2·17	4·22	1·62	1·60
	Injuries and accidents	0·61	0·45	0·56	0·65	0·58	0·77	0·94	0·76	0·86	0·73	0·85	0·63	2·36	0·00	0·77
	All other diseases	1·14	1·06	1·23	0·93	0·78	1·11	1·16	1·10	1·13	1·13	1·51	1·44	3·55	3·17	1·17
	Total	3·36	3·37	3·12	3·31	2·83	3·70	4·11	3·97	3·97	4·20	5·58	4·81	11·57	4·86	4·15
Sick	Upper respiratory infections ..	0·29	0·05	0·32	0·28	0·22	0·19	0·14	0·13	0·13	0·09	0·08	0·10	0·21	0·00	0·15
	Dysenteries and diarrhoea ..	0·02	0·01	0·01	0·01	0·02	0·01	0·01	0·03	0·03	0·07	0·05	0·05	0·06	0·00	0·03
	Skin diseases ..	0·07	0·02	0·05	0·05	0·07	0·11	0·08	0·10	0·11	0·12	0·15	0·12	0·07	0·00	0·10
	Injuries and accidents	0·03	0·05	0·10	0·08	0·12	0·10	0·12	0·10	0·14	0·08	0·10	0·11	0·14	0·00	0·10
	All other diseases	0·12	0·08	0·43	0·20	0·13	0·21	0·17	0·18	0·28	0·18	0·20	0·24	0·28	0·00	0·20
	Total	0·53	0·21	0·91	0·62	0·56	0·62	0·52	0·54	0·69	0·54	0·58	0·62	0·76	0·00	0·58
Total Sent to Hospital ..		0·16	0·15	0·27	0·24	0·35	0·26	0·24	0·31	0·24	0·19	0·32	0·37	0·19	0·00	0·27

the ships rendering these returns were exposed to the different ranges of temperature are illustrated in Fig. 2. The high incidence which occurred when the mean temperature was above 90°F. thus refers to a very small number of the ships and to short periods. The section of the Fleet studied here—77 ships—was exposed to mean noon temperatures ranging between 50° and 60°F., 60° and 70°F., 70° and 80°F., and 80° and 90°F., for about 12 weeks each on the average during the year.

The climatic conditions to which the different classes of ship were exposed during the year also varied considerably. The main battleship and aircraft carrier force was in Home Waters or in the Mediterranean and the mean noon upper deck temperature for the year for each of these groups was 60°F.; but for the cruisers, destroyers, sloops, and frigates which spent more time in tropical and sub-tropical waters, the corresponding mean temperatures were 68°, 70°, 73°, and 74°F. respectively. Information on the effects of the warmer climatic conditions thus relates to men serving in small ships to a greater extent than to men serving in large ships.

"Skin Diseases" and "All Other Diseases" (Fig. 3 overleaf) contribute more than the other groups to the rise in the attending list under the warmer climatic conditions. A rise in the rate for injuries and accidents also occurred when the mean upper deck temperature was above 90°F., although then the numbers were small (7 ship-months). Sickness due to the dysenteries and diarrhoea and to

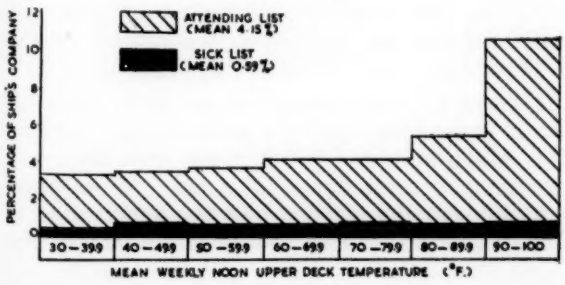

FIG. 1.—Average percentage (for 77 ships) of ship's company on attending and sick lists related to mean weekly upper deck temperature at noon.

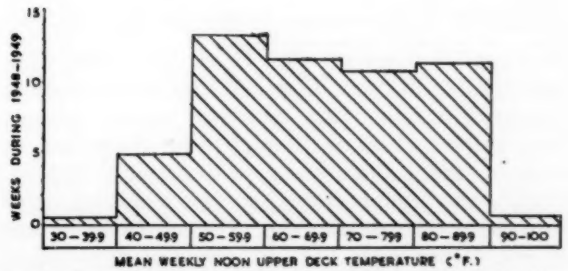

FIG. 2.—Number of weeks in the year 1948–49 for which the 77 ships under investigation were exposed to mean upper deck temperatures at noon ranging between 30° and 100°F.

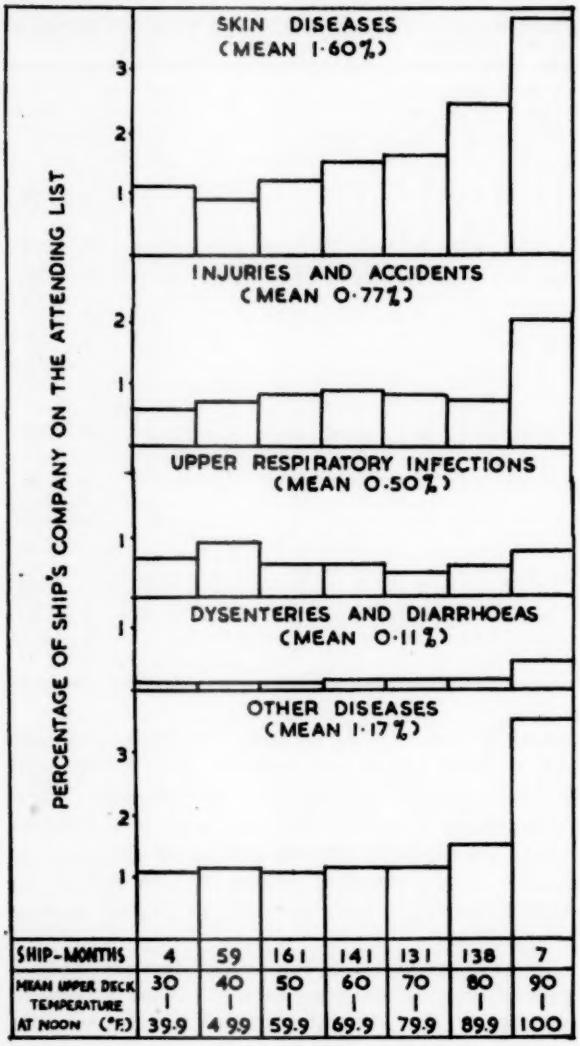
SKIN DISEASES
(MEAN 1·60%)
INJURIES AND ACCIDENTS
(MEAN 0·77%)
UPPER RESPIRATORY INFECTIONS
(MEAN 0·50%)
DYSENTERIES AND DIARRHOEAS
(MEAN 0·11%)
OTHER DISEASES
(MEAN 1·17%)
PERCENTAGE OF SHIP'S COMPANY ON THE ATTENDING LIST
SHIP-MONTHS 4 59 161 141 131 138 7
MEAN UPPER DECK TEMPERATURE AT NOON (°F.) 30 | 39·9 40 | 49·9 50 | 59·9 60 | 69·9 70 | 79·9 80 | 89·9 90 | 100

FIG 3.—Average percentage (for 77 ships) of ship's company on attending list with complaints in the five main disease groups related to mean upper deck temperature at noon.

respiratory illnesses was unaffected by increases in the average air temperature. It would be interesting to know which of the "other diseases" were chiefly responsible for the increase in the attending list.

SICKNESS INCIDENCE AND CLASS OF SHIP.—The data relating to "skin diseases" were re-examined to determine whether the incidence varied between large ships such as battleships, aircraft carriers, or cruisers, small ships such as destroyers, frigates, sloops, and minesweepers, or miscellaneous ships such as depot or repair ships. The results are shown in Fig. 4 (opposite). The incidence of skin disease in sloops and cruisers was more affected by the mean upper deck temperature rising above 80°F. than that in frigates and destroyers, but an upward trend is present for all classes of ship for which adequate relevant data are available when the temperature rose above 80°F. When the mean noon temperature on the upper deck exceeded 80°F., data were available for only 1 ship-month for battleships, 3 ship-months for aircraft carriers, and 4 ship-months for depot ships. Thus on the average the men in these classes of ship may have been less accustomed to warm climates than the men in the smaller classes of ship, and more likely to succumb to minor climatic illnesses.

Evidence on the health of men serving in different classes of ship in warm climates in wartime was obtained from the Eastern Fleet in 1944. The sickness rates were calculated for the common causes of ill health. These showed that depot ships and repair ships were the least healthy, with a mean reporting rate of 29 per 100 man-months: 29 out of every 100 men serving in these ships were entered on the sick or attending lists each month. Battleships and escort carriers were next, with rates of 26 and 25, and small ships and cruisers were the most healthy, each with 17 per 100 man-months. Roberts (1948) also found that depot and repair ships were the least healthy in hot weather during 1945-46, but that there were no differences between the other classes of ship.

SICKNESS INCIDENCE AND STATION.—The total data were examined to determine whether service on different stations affected the health of the peacetime Navy. The main findings are given in Table II (opposite).

The Malayan area is the least healthy, according to these criteria, with total incidences on the attending list and sick list of 7·4 per cent. and 1·1 per cent. respectively. The China, East Indies, and Persian Gulf Stations are next on the list with 5·5 and 0·5 per cent., 5·5 and 0·5 per cent., and 5·2 and 0·45 per cent. respectively. Skin diseases account very largely for the high position of the Malayan area in this list. The Home Fleet and Mediterranean Fleet were almost equally healthy during this period, with attending and sick list incidences of 3·14 and 0·77 per cent., and 3·24 and 0·49 per cent.

The average noon upper deck temperature for the period under examination is given for each station. The Malayan area is the most unhealthy and according to these figures it is also the warmest. But although the average mid-day temperature is much higher on the East Indies Station than on the China Station, the incidences of sickness on the two stations are similar. Thus factors other than the climate may be involved.

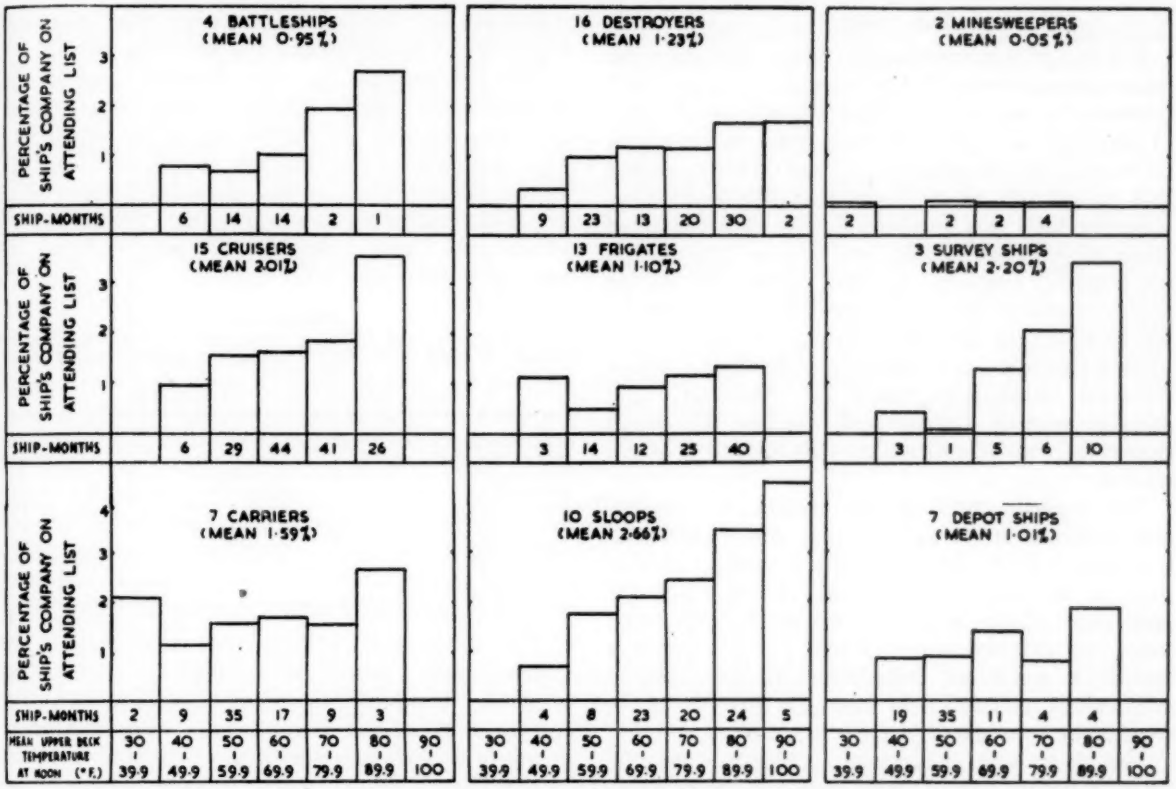
4 BATTLESHIPS (MEAN 0·95%)
16 DESTROYERS (MEAN 1·23%)
2 MINESWEEPERS (MEAN 0·05%)
15 CRUISERS (MEAN 2·01%)
13 FRIGATES (MEAN 1·10%)
3 SURVEY SHIPS (MEAN 2·20%)
7 CARRIERS (MEAN 1·59%)
10 SLOOPS (MEAN 2·66%)
7 DEPOT SHIPS (MEAN 1·01%)
PERCENTAGE OF SHIP'S COMPANY ON ATTENDING LIST
SHIP-MONTHS
MEAN UPPER DECK TEMPERATURE AT NOON (°F.)
30 40 50 60 70 80 90
39·9 49·9 59·9 69·9 79·9 89·9 100

FIG. 4.—Average percentage of ship's company on attending list with skin disease for the nine different classes of ship related to mean upper deck temperature at noon.

TABLE II
MEAN WEEKLY SICKNESS INCIDENCE (PER CENT.) FOR ALL SHIPS ON DIFFERENT STATIONS

Station		China	Malaya	East Indies	West Indies	Mediterranean	Persian Gulf	Home	Miscellaneous	Mean
No. of Ship-months (Total 652)		95	50	15	48	148	30	195	71	
Mean weekly noon upper deck temperatue (°F.)		72·4	84·0	83·2	76·9	67·6	77·2	54·5	68·6	62·8
Attending	Upper respiratory infections	0·64	0·55	0·15	0·45	0·31	0·71	0·53	0·48	0·48
	Dysenteries and diarrhoea	0·17	0·82	0·10	0·08	0·11	0·22	0·07	0·15	0·11
	Skin diseases	2·11	3·23	2·45	1·76	1·27	2·09	0·96	1·71	1·61
	Injuries and accidents	1·08	0·86	0·73	1·05	0·57	0·91	0·63	0·95	0·77
	All other diseases	1·49	1·91	2·10	1·45	0·98	1·29	0·95	1·16	1·18
	Total	5·49	7·37	5·53	4·79	3·24	5·22	3·14	4·45	4·15
Sick	Upper respiratory infections	0·09	0·09	0·03	0·15	0·12	0·11	0·41	0·21	0·15
	Dysenteries and diarrhoea	0·05	0·32	0·06	0·02	0·04	0·04	0·02	0·05	0·03
	Skin diseases	0·07	0·25	0·12	0·12	0·08	0·05	0·07	0·15	0·11
	Injuries and accidents	0·12	0·15	0·09	0·11	0·09	0·09	0·09	0·13	0·10
	All other diseases	0·21	0·30	0·22	0·28	0·16	0·16	0·18	0·19	0·20
	Total	0·54	1·11	0·52	0·68	0·49	0·45	0·77	0·73	0·59
Total Sent to Hospital		0·44	0·27	0·27	0·17	0·26	0·09	0·32	0·24	0·27

Discussion

The aim of this investigation was to determine the relationship between the average noon upper deck temperature and the incidence of sickness in ships of the Fleet serving in different parts of the world, estimated from the numbers of cases on the attending lists or sick lists at midnight each Wednesday (*not* from the total case incidence). The data examined relate to peace-time and not to war-time or the immediately post-war period. Variations in the deployment of ships in different parts of the world, the composition of ships' companies, the strength of the naval force, and operational conditions which influence habitability (such as "blackout" and damage control precautions) prevent the direct comparison of these results with those of earlier studies.

The analysis confirms the finding of war-time and post-war investigations that minor ill-health is greater in ships on tropical or sub-tropical stations than in temperate or northerly waters, but the sparseness of the data available for periods when ships were exposed to hot or cold climatic extremes reveals a need for supplementing the interim conclusions recorded here when the analysis of the returns for subsequent years is available.

The sharp rise in sickness incidence when the mean monthly upper deck mid-day temperature exceeds 80°F. points to the critical levels of warmth which limit a healthy existence afloat. The atmospheric humidity at sea is always high and except in certain machinery compartments or air-conditioned spaces the climate between decks is warm and humid. An air temperature of 80°F. is not uncomfortable for lightly-clothed persons in the tropics, but when this temperature prevails on the upper deck that of the mess-decks is likely to be 6° or 7°F. higher, and yet greater heat will be experienced in many compartments. In a warm humid climate this makes all the difference between a reasonably comfortable thermal environment and one in which the very great majority of people are uncomfortable (Ellis, 1952). This increase in discomfort between decks is associated with an increase in skin diseases and minor ill health.

The greater prevalence of skin diseases amongst ships' companies in the Malayan area than amongst those in the Persian Gulf or on the China Station suggests that a constantly warm humid atmosphere has a more adverse effect on the annual incidence of skin diseases than the diurnal and seasonal cool and warm climatic conditions which pertain on the other stations, although this might be qualified by the fact that in recent years there has been a large increase in the installation of air-conditioning machinery in Persian Gulf ships. The position might have been different a few years ago.

The information on the illnesses which are sensitive to changes in climate—"skin disease" and "all other diseases"—could be amplified with profit. The incidence of the common causes of ill health in the Eastern Fleet when based on Trincomalee in 1944, excluding uncomplicated prickly heat which was very common in many ships, is summarized in Table III.

TABLE III

COMMON CAUSES OF ILL HEALTH IN THE EASTERN FLEET IN 1944 AS SHOWN BY ATTENDANCES AT THE SICK BAY

(Case Incidence per 100 Man-months)

Minor injuries	4·20	Impetigo	0·45
Other skin diseases	3·25	Heat exhaustion	0·42
Boils	2·64	Dyspepsia	0·25
Dysentery	2·63	Bronchitis	0·24
Otitis externa	2·05	Chronic ulcers	0·19
Epidermophytosis	1·91	Pyrexia of unknown origin	0·11
Tinea cruris	1·86	Malaria	0·08
Common cold	1·56	Dermatitis	0·08
Sore throat	0·81	Psychoneurosis	0·06

This shows that boils, fungus infections, otitis externa, and "other skin diseases", comprising septic skin conditions in the main, were responsible for the bulk of the skin diseases. The incidence of minor injuries was also high. Common diseases in the Eastern Fleet, which were not included in the above list but which caused a considerable morbidity, were prickly heat, dengue fever, and infective hepatitis. Venereal diseases, which might account for an increased sickness incidence on some tropical stations, were not included. Thus it would appear from Fig. 3 that "all other diseases" comprises certain conditions sensitive to heat, other than skin diseases and injuries, which at present cannot be identified. The instructions governing future returns might be modified to ask medical officers to include figures for the three or four main sub-groups of "all other diseases", in order to give more information on its make-up.

There is little precise information about the effects of living in a hot climate for a long time on naval health. War-time experience was that minor sickness increased markedly during the first 2 months after ships arrived on a tropical station and then declined to a rather lower level, that it was greater during the warmer seasons, and that it was more prominent during the second year of a tropical commission than the first year. The examination of data, covering the year August 1945–July 1946, showed a sharp rise in the Attending List figures in individual ships after 2 weeks in the tropics and this appeared to reach a maximum after 8 weeks; conversely, in going from the tropics to temperate waters, the

figure fell to normal by the third week (Roberts, 1948).

More evidence of this character would assist discussions on the desirable length of a tropical commission afloat in peace-time; it could be obtained if the current monthly return was supplemented by a statement of the length of time a ship had been in commission in the tropics at the time the return was rendered.

Summary

The incidence of sickness in ships of the Royal Navy during the year October 1, 1948, to September 30, 1949, has been estimated from weekly census counts rendered each month to the Admiralty. This incidence is related to the mean mid-day upper deck temperature.

The percentage of men on the sick list and the numbers sent to hospital did not vary much with changes in the upper deck temperature, but the percentage of men on the attending list increased steadily as the upper deck temperature became warmer, more markedly when it exceeded 80°F., and very markedly when it exceeded 90°F.

The increase in minor ill health at the higher temperatures was largely due to skin diseases, and, when the mean upper deck temperature was above 90°F., to injuries, also. The incidence of skin diseases thus affords a useful guide to the effect of undesirably warm humid climates on health.

When total sickness was considered in relation to the stations from which the reports were rendered, the highest incidence was found to occur in the Malayan area, with those for ships on the China and East Indies Stations and in the Persian Gulf following in that order. The lowest incidence occurred in the Home Fleet, but it differed little from that in the Mediterranean Fleets.

We wish to acknowledge the helpful advice and criticism of Dr. J. A. Fraser Roberts.

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PROPORTION OF FAMILIES SERVED BY A FAMILY DOCTOR

BY

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Conversation with mothers of young children attending Infant Welfare Centres in Smethwick revealed a surprisingly large number who stated that they were registered with a different doctor from their husbands. It was felt that an investigation of the proportion of families served by one general practitioner would be worth while in view of the prominence given to the "family" doctor in current discussions of the medical service.

Material

During an 18-month period in 1951–52, 315 mothers seen by the medical officer at two of Smethwick County Borough's Infant Welfare Centres, were questioned about their medical attendants. No attempt was made to question every mother who attended the centres, but, during this period, most of them had occasion to consult the medical officer, and each was then asked the name of the doctor with whom each member of the family was registered. Latterly, enquiries were also made regarding the doctors attending husband and wife before marriage. The information given could be regarded as accurate, but, occasionally, a wife could not remember the name of her husband's doctor.

Most mothers attending the centres were drawn from working class families and were in the age group 20–35 years.

Results

Of the 315 mothers questioned, ten have been omitted from the survey, either because the husband was in the armed forces or because he had not registered with any doctor. The examination relates, therefore, to 305 families.

Of these 305 families, 153 (50·2 per cent.) had a family doctor, that is to say husband, wife, and children were all registered with the same medical practitioner (Table I); 152 (49·8 per cent.) had no family doctor, but of these families 22 (7·2 per cent.) were registered with different doctors in the same partnership. In Smethwick the majority of the general practitioners are in partnerships of two or three; so that, in a limited sense, these families could claim to possess a family doctor. This leaves 130 families (42·6 per cent.) who had no family doctor in any sense of the term.

TABLE I

PROPORTION OF FAMILIES SERVED BY ONE OR MORE GENERAL PRACTITIONERS

Doctor		One	Two or More Doctors		Total
			In Partnership	Not in Partnership	
Families	Per cent.	50·2	7·2	42·6	100
	Number	153	22	130	305

The medical attendance in these 130 families is shown in Table II. Eleven families claimed the services of three doctors; each parent had a different doctor and a third doctor looked after the children. In 107 families the children were registered with the mother's doctor. This is, perhaps, to be expected, since the mother is usually responsible for taking an ailing child to the doctor's surgery or for asking for a domiciliary visit. In only seven families were the children registered with the father's doctor.

TABLE II

MEDICAL ATTENDANCE IN FAMILIES SERVED BY TWO OR MORE GENERAL PRACTITIONERS NOT IN PARTNERSHIP

Husband and Wife	With different Doctors				With same Doctor	Total
Children	With Father's Doctor	With Mother's Doctor	Some with Father's some with Mother's Doctor	With a Third Doctor	With a Different Doctor	
Per cent.	5·4	82·3	1·5	8·5	2·3	100
Number	7	107	2	11	3	130

TABLE III

MEDICAL ATTENDANCE IN FAMILIES SERVED BY ONE GENERAL PRACTITIONER

Changes after Marriage	Wife changed to Husband's Doctor	Husband changed to Wife's Doctor	Both changed to Different Doctor after Marriage	No Change (Both had Same Doctor before Marriage)	Total
Number	26·4	24·5	38·7	10·4	100
Per cent.	28	26	41	11	106*

* 47 of the 153 families served by one general practitioner have been excluded because information was incomplete.

In the remaining five families one or more children had a different doctor from the parents or one child was under the father's doctor and one under the mother's doctor.

Information regarding the 153 families served by a family doctor is incomplete, since, at the beginning of the survey, questioning did not include details of medical attendants before marriage. Information about 106 of these families, however, is available (Table III). In 26 cases the husband changed to the wife's doctor on marriage; in 28 cases the wife changed to the husband's doctor; in 41 cases both partners changed to a new doctor. In eleven cases both husband and wife had the same doctor before and after marriage. Further information would be required before much significance could be attached to these figures.

DISCUSSION

This survey relates to a selected group of families in a densely populated urban area. The finding that only half the families possess a family doctor is of interest, but may not be a true reflection of the situation throughout Great Britain. In a rural community, for example, one imagines that nearly everyone is registered with the same doctor, usually because he is the only doctor in the area; and in a well-to-do residential district the proportion of families served by a family doctor is also likely to be higher.

The commonest finding among the 152 families not possessing a family doctor is that the mother and father have different doctors, and that each keeps the doctor with whom he or she was registered before marriage. When children are born they are usually registered with the mother's doctor.

It was not possible to enquire in detail about motives governing choice of practitioner. Only two mothers volunteered the information that they thought it desirable to have a family doctor. Mothers with young children often stated that they had changed to a particular doctor because he was interested in children. In some cases the choice of doctor seemed quite haphazard. For example a man who came from Ireland to join his family attempted to consult his wife's practitioner, but finding he was not available crossed the road and became registered with another doctor.

SUMMARY

When 305 mothers attending welfare clinics were questioned, it was found that in only half the related families were all members registered with the same general practitioner.

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WEIGHT AT THIRD BIRTHDAY RELATED TO BIRTH WEIGHT, DURATION OF GESTATION, AND BIRTH ORDER*

BY

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It is now well recognized that the weight of children during the first few years of life is closely related to their weight at birth. This point has been made by Illingworth in a number of publications (Illingworth, 1939 and 1950; Illingworth, Harvey, and Gin, 1949; Illingworth, Harvey and Jowett, 1950), and has been confirmed recently by Parfit (1951) and by Norval, Kennedy, and Berkson (1951). In general it appears that if infants are grouped according to birth weight, the mean weights of the groups retain the same order at least until the third birthday, and the differences between the groups remain not less than they were at birth.

Birth weight is directly related both to duration of gestation and to birth order. The studies mentioned above, however, ignore the possible influence of these two variables upon subsequent rate of growth, and it is the purpose of this communication to examine their influence upon weight at the third birthday.

Material

Data collected on all births (23,970) delivered in Birmingham during 1947 have already been used in investigation of duration of gestation, birth weight, birth order, survival, etc. Birth weight and duration of gestation were recorded for 16,163 single births known to have survived the first year of life (Gibson and McKeown, 1951). For the present purpose the record cards of these births were sorted according to duration of gestation (four groups) and birth weight (eight groups), and samples were taken from each of these groups in such a way that the less common birth weights and durations of gestation were well represented (see Appendix, p. 82). Thus, in the birth weight group 5½–6½ lb., the sample included all infants of less than 35 weeks, one-fifth of those of 35–38 weeks, one-tenth of those of 39–42 weeks, and all of 42 or more weeks gestation. The record cards carried consecutive identification numbers, which, so far as could be determined, were independent of the variables under consideration, and a method which used the last two digits of these numbers was devised to ensure that the fractional samples were taken at random.

By this method we obtained the names and addresses of 2,302 infants of known birth date, birth weight, and duration of gestation, who were born alive in Birmingham during 1947. During 1950 one of two social workers attempted to visit each of these children within 10 days of the third birthday. At each successful visit the following information was recorded: unclad weight in pounds and ounces (taken on portable scales); standing height in inches (measured on a steel rule); duration of breast feeding and history of morbidity during the first 3 years of life (obtained from the mother).

Information was collected in this way for 1,782 (77 per cent.) of the sample of 2,302 children, and the analysis which follows is based on 927 boys and 855 girls of known birth weight and duration of gestation who were visited, weighed, and measured within 10 days of their third birthdays.

Weight at Third Birthday Related to Birth Weight and Duration of Gestation

In Table I (opposite) mean weights of male and female children at the third birthday are related to duration of gestation and birth weight. The mean weights of children in column and row totals have not been given, since the sampling procedure adopted makes this summation of doubtful value. Although unqualified means are not satisfactory summarizing indices of small numbers of rather widely dispersed measurements, the Table confirms the observation that third birthday weight is closely related to birth weight; for both sexes, mean weight at the third birthday increases by approximately one pound for each pound increase in weight at birth.

By the third birthday male children are, on the average, about one pound heavier than female children of the same birth weight. There is no very obvious association, however, between mean weight and duration of gestation.

* This research was assisted by a grant from the Birmingham University Students' Social Services Fund.

TABLE I
MEAN WEIGHT (lb.) AT THIRD BIRTHDAY RELATED TO BIRTH WEIGHT AND DURATION OF GESTATION

Birth Weight (lb.)	Duration of Gestation (wks)							
	Males				Females			
	<35	35–38	39–42	43 and Over	<35	35–38	39–42	43 and Over
<4½	30·9 (20)	28·5 (17)	29·3 (5)	—	29·5 (20)	27·8 (25)	30·8 (10)	—
4½–	30·8 (27)	30·7 (32)	30·0 (21)	29·1 (4)	29·6 (29)	30·3 (48)	30·0 (43)	27·3 (2)
5½–	33·0 (25)	31·6 (44)	31·6 (39)	30·4 (22)	30·4 (26)	30·6 (48)	30·8 (63)	30·0 (39)
6½–	31·6 (34)	32·9 (27)	31·8 (38)	32·8 (45)	32·3 (25)	31·5 (36)	31·5 (47)	31·6 (60)
7½–	33·6 (17)	33·7 (53)	34·6 (42)	33·5 (68)	32·5 (17)	34·5 (37)	32·4 (33)	32·7 (51)
8½–	36·7 (9)	34·8 (32)	34·7 (102)	34·7 (41)	32·9 (2)	33·7 (20)	34·2 (59)	33·3 (24)
9½–	36·6 (3)	36·3 (25)	34·7 (56)	34·4 (19)	32·0 (1)	35·6 (9)	33·4 (32)	34·2 (16)
10½ and Over	—	35·5 (4)	37·0 (48)	34·2 (8)	—	36·6 (2)	36·3 (24)	32·8 (7)

Numbers in brackets are numbers of children upon which means are based.

Since length at birth had not been recorded, we were unable to compare standing height with this measurement. Table II therefore makes the less satisfactory comparison between mean height and birth weight and duration of gestation. On the average, male children are a little taller than female children of the same birth weight. But when the sexes are considered separately, the third birthday measurement is again seen to be related to birth weight, and although the association is a little irregular, mean height increases fairly regularly with increasing birth weight.

TABLE II
MEAN LENGTH (in.) AT THIRD BIRTHDAY RELATED TO BIRTH WEIGHT AND DURATION OF GESTATION

Birth Weight (lb.)	Duration of Gestation (wks)							
	Males				Females			
	<35	35–38	39–42	43 and Over	<35	35–38	39–42	43 and Over
<4½	36·7	35·7	36·7	—	35·6	35·4	36·1	—
4½–	36·3	36·8	36·2	34·7	36·0	36·3	36·0	34·5
5½–	37·5	36·7	36·7	36·0	36·3	36·5	36·5	36·2
6½–	36·6	37·5	37·3	37·1	36·9	36·7	36·8	36·8
7½–	37·4	37·5	37·5	37·3	37·2	37·4	37·0	36·8
8½–	37·5	37·8	37·6	37·7	37·0	38·0	37·4	37·4
9½–	37·5	38·1	37·8	37·3	35·5	37·3	37·2	37·4
10½ and Over	—	37·0	38·3	37·5	—	38·5	37·9	36·9

The fact that mean weight at third birthday increases by about the same amount as the birth weight (Table I) suggests that mean increase in weight (difference between third birthday weight and birth weight) may be independent both of birth weight and of duration of gestation. This possibility is explored and confirmed in Table III. Indeed, in this Table there is so little association between mean weight increment and either birth weight or duration of gestation, that, in this instance, there can be no great objection to summing rows and columns. The mean increase in weight is then 25·4 lb. for males and 24·6 lb. for females.

TABLE III
MEAN INCREASE IN WEIGHT (lb.) BY THIRD BIRTHDAY RELATED TO BIRTHWEIGHT AND DURATION OF GESTATION

Birth Weight	Duration of Gestation (wks)							
	Males				Females			
	<35	35–38	39–42	43 and Over	<35	35–38	39–42	43 and Over
<4½	26·3	24·5	25·4	—	25·9	23·8	26·8	—
4½–	26·0	25·6	25·1	24·0	24·9	25·2	23·8	22·0
5½–	27·0	25·8	25·7	24·4	24·4	24·7	24·7	23·9
6½–	24·8	26·0	25·0	25·6	25·5	24·6	24·7	24·7
7½–	25·7	26·0	26·8	25·5	25·0	26·8	24·3	24·8
8½–	28·3	26·3	25·7	25·8	24·0	25·1	25·3	24·3
9½–	27·0	26·4	24·9	24·5	23·0	25·9	23·7	24·6
10½ and Over	—	25·9	26·0	23·2	—	26·0	25·7	21·0

To carry this point a little further, the relationship between third birthday weight and birth weight has been summarized by fitting lines to the raw data by the method of least squares (Table IV). The equations for all males ($y = 1{\cdot}0x + 25{\cdot}3$) and for all females ($y = 1{\cdot}0x + 24{\cdot}6$) again suggest that, whatever the birth weight, by the third birthday males had gained about 25½ lb. on the average and females about 24½ lb.

TABLE IV
EQUATIONS SHOWING RELATIONSHIP BETWEEN WEIGHT AT THIRD BIRTHDAY (y) AND BIRTH WEIGHT (x)

Duration of Gestation (wks)	Males	Females
<35	$y = 0{\cdot}9x + 26{\cdot}7$	$y = 0{\cdot}9x + 25{\cdot}8$
35–38	$y = 1{\cdot}3x + 23{\cdot}8$	$y = 1{\cdot}3x + 23{\cdot}3$
39–42	$y = 1{\cdot}1x + 24{\cdot}7$	$y = 1{\cdot}1x + 24{\cdot}1$
43 and Over	$y = 1{\cdot}0x + 25{\cdot}4$	$y = 0{\cdot}9x + 25{\cdot}1$
All Durations	$y = 1{\cdot}0x + 25{\cdot}3$	$y = 1{\cdot}0x + 24{\cdot}6$

Weight at Third Birthday Related to Birth Order

Most writers are agreed that birth weight increases with birth rank. McKeown and Gibson (1951) recorded the following mean birth weights for the 1947 Birmingham births:

Birth Rank	1	2	3	4 and Over	Total
Mean Birth Weight (lb.)	7·17 ±0·01	7·46 ±0·02	7·65 ±0·03	7·65 ±0·03	7·41 ±0·01

Examination of the present sample of the same births indicated that by the third birthday firstborn children had more than compensated for their initial handicap; it is shown in Table V that mean weight is higher for first than for later births (see also the Figure). This negative association between birth order and rate of growth is also seen in Table VI (opposite). The correlation between birth weight and birth order (duration of gestation held constant) is +0·23 for males and +0·24 for females; the correlation between third birthday weight and birth order (birth weight and duration of gestation held constant) is −0·17 and −0·22.

Table VI illustrates a number of other points. In the first place it confirms that weight at third birthday is highly correlated with birth weight (males +0·49 and females +0·50, with duration of gestation and birth order held constant). Secondly, and perhaps of more interest, there is a small negative correlation (males −0·10 and females −0·07) between third birthday weight and duration of gestation, when birth weight and birth order are held constant. This is not apparent in Table I, but it might be expected that for a given birth weight and birth order infants of short durations of gestation would gain weight a little more rapidly than infants of longer durations of gestation. Finally, when birth weight is held constant, birth order and duration of gestation are inversely related. The correlation is small and, practically speaking, of little importance (males −0·07 and females −0·02); a similar association has recently been reported by Karn and Penrose (1951).

Table V

MEAN WEIGHT (lb.) AT THIRD BIRTHDAY RELATED TO BIRTH WEIGHT AND BIRTH ORDER

Birth Weight (lb.)	Birth Order					
	Males			Females		
	1	2 and 3	4 and Over	1	2 and 3	4 and Over
<4½	29·8 (26)	30·7 (9)	28·6 (7)	28·9 (22)	29·2 (25)	28·2 (8)
4½–	30·7 (36)	30·3 (33)	30·4 (15)	29·9 (66)	29·5 (40)	28·5 (15)
5½–	31·8 (61)	31·4 (52)	31·3 (15)	31·0 (93)	30·4 (57)	28·9 (26)
6½–	32·7 (67)	32·2 (57)	30·8 (19)	32·0 (79)	31·9 (58)	30·4 (30)
7½–	34·9 (59)	33·5 (89)	32·6 (31)	33·9 (48)	32·8 (68)	32·2 (22)
8½–	36·4 (55)	34·4 (82)	33·8 (46)	34·1 (22)	33·8 (59)	33·0 (24)
9½–	36·2 (18)	35·9 (47)	33·5 (38)	35·0 (9)	34·0 (29)	33·5 (20)
10½ and Over	38·9 (6)	37·7 (25)	35·0 (29)	40·9 (2)	37·2 (12)	34·0 (19)

Birth order was unknown for six of the 1,782 children traced.

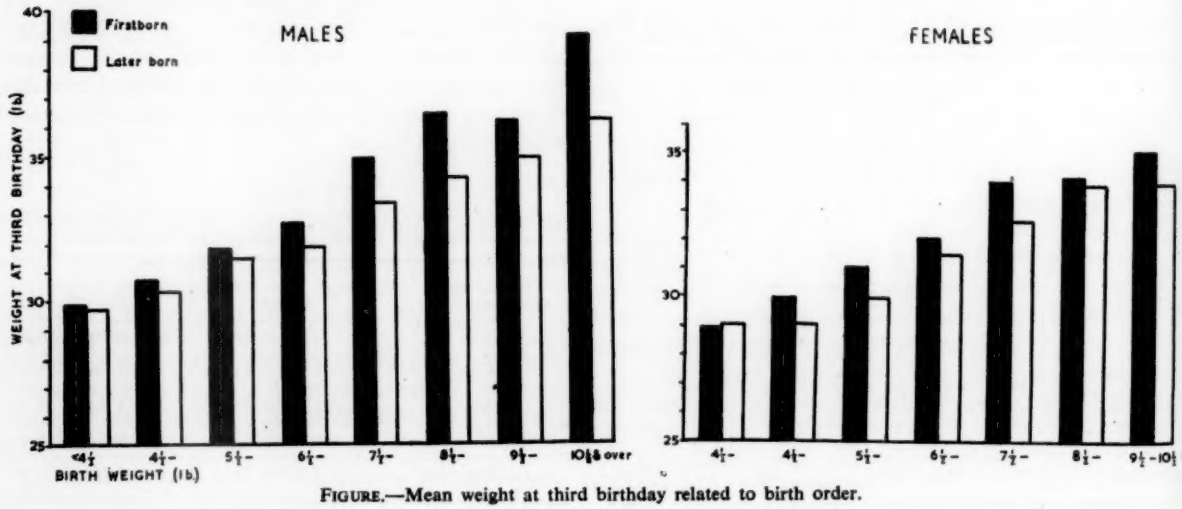

FIGURE.—Mean weight at third birthday related to birth order.

TABLE VI

PARTIAL CORRELATION COEFFICIENTS (SHOWING ASSOCIATION BETWEEN WEIGHT AT THIRD BIRTHDAY BIRTH WEIGHT, DURATION OF GESTATION, AND BIRTH ORDER)

Correlated Variables		Variables Held Constant	Correlated Coefficients	
			Males	Females
Weight at third birthday and:	(*a*) Birth weight	Duration of gestation and Birth order	+0·49	+0·50
	(*b*) Duration of gestation	Birth weight and Birth order	−0·10	−0·07
	(*c*) Birth order	Birth weight and Duration of gestation	−0·17	−0·22
Birth weight and:	(*a*) Duration of gestation	Birth order	+0·38	+0·36
	(*b*) Birth order	Duration of gestation	+0·23	+0·24
Duration of gestation and:	Birth order	Birth weight	−0·07	−0·02

DISCUSSION

Two points of interest arise out of this inquiry. The first is that rate of post-natal growth is relatively independent of duration of gestation although it is closely related to weight at birth. Parfit (1951) has recently reported that weight increment (actual amount of weight gained since birth) is a function of sex but not of birth weight, and has suggested that in welfare clinics weight increment might be plotted on a chart on which birth weight is recorded as zero, and the expected range of values for weight increments indicated by a zone. Our own observations also suggest that this would be an improvement on the current practice of plotting weight against a so-called normal weight curve. The procedure in effect would standardize for variation in rate of growth attributable to variation in birth weight. But the difficulty of interpreting individual departures from a growth curve derived from mean values in a mixed population would remain.

The second point of interest is the association between rate of post-natal growth and birth order. It is well recognized that birth weight increases with birth order, and since there is no reason to suppose that genetic constitution is related to birth rank, this association must be attributable to differences in the pre-natal environment. But we have shown that the pre-natal growth rates of first and later births are reversed after birth, so that by the third birthday, weight is inversely related to birth rank. This change must be attributable to differences in the post-natal environment, and it is easy to suggest examples of post-natal influences related to family size which might be expected to have an effect on a child's rate of growth. For example the economic circumstances of families are closely related to the number of children, and the incidence of infection in the first year of life rises sharply with birth order (Gibson and McKeown, 1952).

SUMMARY

For 927 boys and 855 girls of known birth date, birth weight, and duration of gestation, weight and standing height were recorded within 10 days of the third birthday.

Mean weight at the third birthday was closely related to birth weight; the correlation between these variables, when duration of gestation and birth order were held constant, was +0·49 for males, and +0·50 for females.

There was no obvious association between mean weight at third birthday and duration of gestation, but there was a small negative correlation between third birthday weight and gestation when birth weight and birth order were held constant.

The relationship between third birthday weight and birth weight was summarized by fitting lines to the raw data by the method of least squares. The result ($y = 1{\cdot}0x + 25{\cdot}3$ for males, and $y = 1{\cdot}0x + 24{\cdot}6$ for females) suggested that, on the average, whatever the birth weight or duration of gestation, males had gained about 25½ lb. and females about 24½ lb. by the third birthday.

Weight at birth increased with birth order, but by the third birthday firstborn children of all birth weights were heavier, on the average, than children of higher birth ranks. The correlation between birth weight and birth order (duration of gestation held constant) was +0·23 for males, and +0·24 for females; between the third birthday weight and birth order (birth weight and duration of gestation held constant) the correlation was −0·17 for males, and −0·22 for females.

We gratefully acknowledge our indebtedness to Mrs. M. Hopper and Miss M. Smith, who visited, weighed and measured all the children included in this survey.

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APPENDIX

DETAILS OF SAMPLE SELECTED FROM 16,163 SINGLE BIRTHS OF KNOWN BIRTH WEIGHT AND DURATION OF GESTATION DELIVERED IN BIRMINGHAM DURING 1947

Birth Weight (lb.)	Duration of Gestation (wks)															
	<35				35–38				39–42				43 and Over			
	Number of births	Sampling fraction	Percentage of sample traced	Number traced	Number of births	Sampling fraction	Percentage of sample traced	Number traced	Number of births	Sampling fraction	Percentage of sample traced	Number traced	Number of births	Sampling fraction	Percentage of sample traced	Number traced
<4½	59	1	68	40	52	1	81	42	21	1	71	15	—	—	—	—
4½–	73	1	77	56	214	0·5	75	80	181	0·5	70	64	10	1	60	6
5½–	68	1	75	51	670	0·2	74	92	1,380	0·1	81	102	98	1	62	61
6½–	87	1	68	59	990	0·1	75	63	4,145	0·02	91	85	292	0·5	72	105
7½–	48	1	71	34	574	0·2	73	90	4,236	0·02	95	75	316	0·5	78	119
8½–	12	1	92	11	158	0·5	78	52	1,666	0·1	85	161	148	0·5	78	65
9½–	5	1	80	4	51	1	63	34	465	0·2	80	88	46	1	76	35
10½–	—	—	—	—	7	1	86	6	73	1	99	72	18	1	83	15

CORRIGENDUM

It is regretted that a misprint occurred in Equation (*vii*) on p. 19 of the January issue of the Journal in the article on "Mortality from Tumours of the Urinary Bladder", by R. A. M. Case. Equation (*vii*) should read:

$$R(Z.w.X) = [\text{Anti-probit } Y(b.Z.X)]\,[0{\cdot}5483 + 0{\cdot}00178Z + 0{\cdot}0119\,(w - 1935)] \div 100$$

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INFLUENCE OF BIRTH ORDER AND MATERNAL AGE ON THE HUMAN SEX RATIO AT BIRTH

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Introduction

Lewis and Lewis (1905) and Knibbs (1917) noted that first births contained relatively more males than subsequent births. Russell (1936) and Ciocco (1938), using data from United States vital statistics, found decreasing sex ratio with increasing birth orders up to the fifth. Ciocco did not examine individual parities after the fifth, but Russell found no decrease in sex ratio after the sixth birth rank.

Examinations of association of sex ratio with parental age have also demonstrated fairly consistent trends, although there has been difference of opinion whether the association is with age of father or with age of mother. Decrease in masculinity with increasing age of one or other parent has been shown by Wicksell (1926), Russell (1936), Ciocco (1938), Martin (1943), and Lowe and McKeown (1950). From British statistics, the last authors showed that the trend with maternal age in stillbirth sex ratio was the inverse of that for live births, and that this opposite trend was due largely, if not entirely, to variation in the distribution of stillbirths by cause at different maternal ages. However, their data did not permit examination of association with birth order.

Data published since the reports of Russell and Ciocco, by the United States Bureau of the Census, and by the National Office of Vital Statistics' permit us to re-examine associations with maternal age and birth order for live births and stillbirths, but related information on cause of stillbirth is not available. In view of the observation of Ciocco that sex ratios of whites and non-whites are substantially different, these two groups are here considered separately. For the reasons given by Lowe and McKeown (1950), sex ratios are expressed as per cent. male.

White Births

Sex ratios of white live births, stillbirths, and total births in the United States are given by birth order in Table I and by maternal age in Table II. Data on stillbirths are not available by birth order for 1945, or by maternal age for 1948 and 1949. By definition, the group "stillbirths" contains no foetal death delivered before the fifth month of gestation. Since notification requirements vary from state to state with regard to duration of gestation, the group does not contain all foetal deaths delivered after this month, but there is no reason to believe that the selection is biased as regards birth order or maternal age.

TABLE I
SEX RATIO OF WHITE BIRTHS BY BIRTH ORDER, U.S.A., 1942–44 AND 1946–49

Birth Order	Live Births		Stillbirths		Total Births	
	No. of Births	Sex Ratio	No. of Births	Sex Ratio	No. of Births	Sex Ratio
1	7,397,413	51·62	139,340	54·67	7,536,753	51·68
2	5,412,077	51·45	74,176	54·37	5,486,253	51·49
3	2,769,615	51·31	48,074	54·72	2,817,689	51·37
4 and 5	2,124,443	51·26	48,618	54·68	2,173,061	51·34
6 and over	1,258,948	51·14	44,086	55·03	1,303,034	51·27
Total	19,888,699*	51·46	396,376*	54·68	20,285,075*	51·52

* Includes 926,203 live births and 42,082 stillbirths of unspecified birth order.

TABLE II
SEX RATIO OF WHITE BIRTHS BY MATERNAL AGE, U.S.A., 1942–47

Maternal Age	Live Births		Stillbirths		Total Births	
	No. of Births	Sex Ratio	No. of Births	Sex Ratio	No. of Births	Sex Ratio
19 and under	1,549,223	51·59	28,969	55·48	1,578,192	51·66
20–24	5,109,515	51·54	82,432	54·49	5,191,947	51·59
25–29	4,654,280	51·52	82,621	54·62	4,736,901	51·57
30–34	2,937,373	51·35	67,311	54·58	3,004,684	51·42
35–39	1,443,776	51·32	46,562	55·18	1,490,338	51·44
40 and over	400,888	51·14	19,537	54·60	420,425	51·31
Total	16,120,225*	51·47	338,421*	54·80	16,458,646*	51·54

* Includes 25,170 live births and 10,989 stillbirths of unspecified maternal age.

The Tables show that sex ratios of live births and total births decrease regularly both with birth order and with maternal age.

The sex ratio of total births (live- and still-born) is that of all births expelled from the uterus at a time when notification is required. Since this is the

closest direct estimate of the sex ratio at conception, separate examination of the influences of birth order and maternal age for total births would be desirable. However, the necessary data are not available for stillbirths, and the examination must be limited to live births, which in the present data do not differ greatly from total births in their overall associations. Table III gives the sex ratios of live births at different birth orders and maternal ages. It may be seen that sex ratios fall with parity for each maternal age group, but that there is no consistent association with maternal age when individual birth orders are considered. The data suggest therefore that there is little direct relationship between maternal age and the sex ratio of live births.

TABLE III
SEX RATIO OF WHITE LIVE BIRTHS BY BIRTH ORDER AND MATERNAL AGE, U.S.A., 1942–49

Maternal Age	Birth Order					Total
	1	2	3	4 and 5	6 and over	
19 and under	51·65	51·54	51·30	—	—	51·62
20–24	51·62	51·43	51·31	51·33	(51·28)	51·52
25–29	51·63	51·51	51·37	51·31	51·16	51·48
30–34	51·53	51·44	51·21	51·23	51·17	51·34
35–39	51·45	51·41	51·34	51·36	51·14	51·30
40 and over	(51·84)	51·57	51·19	51·12	50·90	51·15
Total ..	51·62	51·47	51·31	51·29	51·11	51·46

Estimates based on less than 50,000 births are given in brackets.
No estimate is given for cells containing less than 25,000 births.

Although Russell (1936) found no decrease in sex ratio for birth ranks after the fifth, the larger numbers now available indicate that the sex ratio of live births decreases steadily from 51·62 in the first birth rank to 51·03 at birth ranks "8 and over" (606,712 births). Examination of individual birth ranks after the eighth shows some irregularity, possibly due to small numbers, but suggests that sex ratios do not fall substantially after this birth rank.

For stillbirths the association of sex ratio with birth rank has not previously been examined, but Lowe and McKeown (1950) investigated the maternal age association. Our results, shown in Table II, confirm their findings of an increase in sex ratio with advancing maternal age after age 19. However, their figures did not show the presently observed high sex ratio in the age group "19 and under", for which their numbers were small. In the present series, the difference between the age groups "19 and under" and "20–24" is not likely to have arisen by chance ($0·99 \pm 0·34$). Association with birth order is similar (Table I), with decrease in sex ratio from birth rank 1 to birth rank 2 and then increase with increasing birth rank. Unfortunately, present sources do not give birth rank, sex, and maternal age simultaneously for stillbirths.

NON-WHITE BIRTHS

For non-white births, Tables IV, V, and VI give similar data to that already recorded for whites (see also Figs 1 and 2, opposite). We may note that for non-whites:

(1) In live births and total births, sex ratios are lower than in whites, but for stillbirths they are higher. The latter difference would be exaggerated if sex ratios were calculated from sex-specific stillbirth rates.

(2) As in whites, sex ratios of live births show no consistent relationship to maternal age, but display fairly

TABLE IV
SEX RATIO OF NON-WHITE BIRTHS BY BIRTH ORDER, U.S.A., 1942–44 AND 1946–49

Birth Order	Live Births		Stillbirths		Total Births	
	No. of Births	Sex Ratio	No. of Births	Sex Ratio	No. of Births	Sex Ratio
1	750,874	50·68	29,237	56·62	780,111	50·90
2	559,525	50·81	16,071	55·99	575,596	50·95
3	380,001	50·63	11,668	55·31	391,669	50·77
4 and 5	454,969	50·52	15,999	55·54	470,968	50·69
6 and over	485,477	50·50	26,045	55·67	511,522	50·76
Total	2,733,176*	50·64	108,999*	55·93	2,842,175*	50·84

* Includes 102,330 live births and 9,979 stillbirths of unspecified birth order.

TABLE V
SEX RATIO OF NON-WHITE BIRTHS BY MATERNAL AGE, U.S.A., 1942–47

Maternal Age	Live Births		Stillbirths		Total Births	
	No. of Births	Sex Ratio	No. of Births	Sex Ratio	No. of Births	Sex Ratio
19 and under	488,352	50·69	18,153	56·98	506,505	50·92
20–24	679,709	50·67	23,256	56·02	702,965	50·85
25–29	451,897	50·61	17,476	55·76	469,373	50·81
30–34	284,987	50·59	13,891	55·76	298,878	50·83
35 and over	226,395	50·37	14,725	56·19	241,120	50·72
Total	2,142,499*	50·62	90,754*	56·15	2,233,253*	50·85

* Includes 11,159 live births and 3,253 stillbirths of unspecified maternal age.

TABLE VI
SEX RATIO OF NON-WHITE LIVE BIRTHS BY BIRTH ORDER AND MATERNAL AGE, U.S.A., 1942–49

Maternal Age	Birth Order					Total
	1	2	3	4 and 5	6 and over	
19 and under	50·66	50·74	(50·64)	—	—	50·65
20–24	50·77	50·71	50·68	50·44	(50·53)	50·67
25–29	50·59	50·92	50·41	50·57	50·44	50·59
30–34	(50·50)	(51·23)	(50·92)	50·65	50·55	50·67
35 and over	—	—	—	(50·38)	50·36	50·39
Total ..	50·68	50·78	50·64	50·51	50·45	50·62

Estimates based on less than 50,000 births are given in brackets.
No estimate is given for cells containing less than 25,000 births.

consistent trends with birth rank when the association between maternal age and birth order is separated.

(3) The effect of birth rank differs from that noted for whites, in that the sex ratio first increases from birth rank 1 to birth rank 2 before decreasing with increasing birth order.

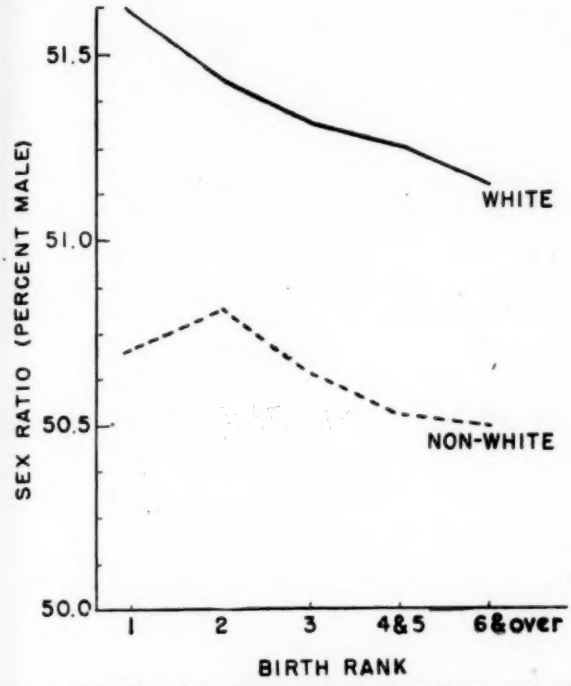

FIG. 1.—Sex ratio of live births by birth order, U.S.A., 1942–44 and 1946–49.

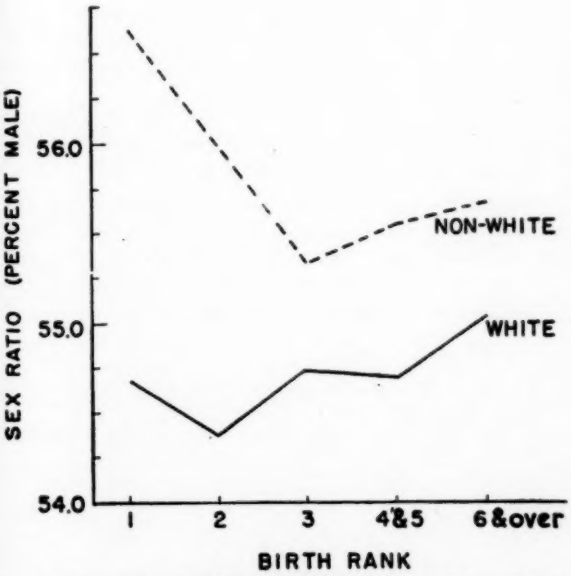

FIG. 2.—Sex ratio of stillbirths by birth order, U.S.A., 1942–44 and 1946–49.

(4) For stillbirths, trends are similar to those observed in whites, except that the lowest masculinity is seen in birth rank 3 (instead of 2), and at ages 25–34 (instead of 24 and under).

Observed difference between sex ratios of white and non-white stillbirths should be interpreted with some caution, since non-white stillbirths are reported less frequently than white, and reported births may be biased in respect of sex. In addition, at early gestational ages sex reporting may be less accurate in non-whites than in whites.

DISCUSSION

These data, based as they are on large numbers of births, enable us to say with some confidence that maternal age is not associated with the sex ratio of live births except indirectly through the interdependence of maternal age and birth order. This is surprising, since many causes of stillbirth (and also presumably of abortion) are associated with maternal age. It suggests that these latter causes of foetal death do not greatly influence the sex ratio, either because they have no pronounced sex ratio, or because they are not common in early foetal life. Observed variations in stillbirth sex ratio with age and birth order are insufficient to account for trends in the sex ratio of livebirths, and search must be made for some feature or features of early foetal death (prior to the time of notification) which might do so. If the trends noted are not due to variation in the sex ratio at conception, the data here presented indicate that cause should be sought in relatively common conditions associated with birth order. It may be pertinent to point out that anencephalus is at least one cause of foetal death which is associated with birth order but not with maternal age (Record and McKeown, 1949), a fact which almost certainly accounts for a considerable number of previable or prenotification foetal deaths, and which shows moreover a higher proportion of females in first than in subsequent birth ranks (MacMahon and McKeown, 1952). Without direct evidence, however, it would be unwise to assume that cases of anencephalus which abort in early stages of pregnancy exhibit associations similar to those of cases which come to attention in later months.

The variation in the sex ratio of live births cannot be explained by magnifying the trends seen for stillbirths on the assumption that such trends will be similar for previable foetal deaths, since, neither for whites nor for non-whites, is the trend for live births the inverse of that for stillbirths (Figs 1 and 2). Nor would it be reasonable to expect that such an

explanation would account for variations in the live birth sex ratio, since some common causes of stillbirth which have marked sex ratios (*e.g.* difficult labour) clearly do not operate in early foetal life.

The increase in sex ratio noted in many countries after the first world war and during the second has been attributed by Martin (1943) among others to a lower age at marriage with a consequent lower maternal age at delivery. Evidence already presented here suggests that this is unlikely, but indicates the possibility that variations in birth rank distribution may have been responsible. For England and Wales where the trend was noted in both wars, the Registrar-General does not give numbers of births by birth order and sex, but the numbers of legitimate maternities have been available by birth order since the latter part of 1938. Table VII gives the sex ratio of legitimate total births and the percentage of all legitimate maternities of the first birth rank in 2-year groups for 1937–48. There is no association between the secular trend in sex ratio and the proportion of first births. By applying sex ratios for individual birth orders, 1, 2, 3, 4, and 5, and 6 and over, derived from United States data for whites (Table I), to the respective number of maternities in England and Wales occurring at each birth order, we may obtain expected sex ratios during the time under consideration; the expected sex ratios (Table VII, last column) show the trend which would have occurred with observed changes in birth rank distribution if there had been no secular change in sex ratios of individual birth ranks.

TABLE VII
SECULAR CHANGES IN SEX RATIO OF TOTAL BIRTHS IN ENGLAND AND WALES, 1937–48

Years	Sex Ratio of Legitimate Births	Percentage of Legitimate Maternities Primiparous	Expected Sex Ratio*
1937–38	51·42	—	—
1939–40	51·42	42·56	51·52
1941–42	51·49	44·89	51·53
1943–44	51·60	42·46	51·53
1945–46	51·52	41·30	51·53
1947–48	51·55	43·05	51·53

* Calculated by applying to the numbers of maternities of 1st, 2nd, 3rd, 4th and 5th, and 6th and over, birth rank, the sex ratios for each birth rank shown in Table I, and totalling for each 2-year period (see text).

There is practically no variation from year to year, and, unless the association between sex ratio and birth order is much stronger in England and Wales than for white births in the United States, we may conclude that the increased sex ratio during the war years was probably not the result of changing birth rank distribution of births. This conclusion is supported by the fact that illegitimate births, for which marked changes in birth rank distribution seem less likely than for legitimate births, show the secular trend to an even greater extent than legitimate births (Fig. 3).

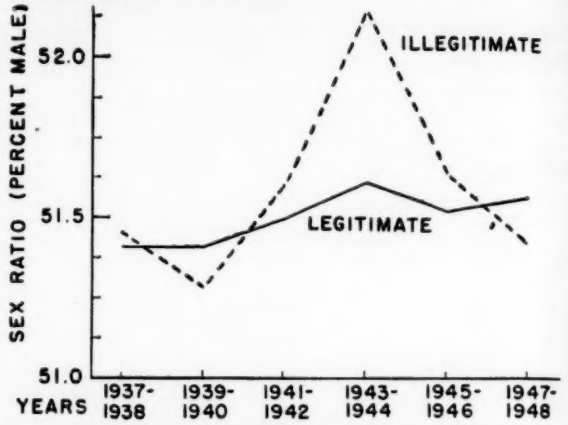

FIG. 3.—Secular change in legitimate and illegitimate total birth sex ratio, England and Wales, 1937–48.

SUMMARY

Data from the United States Bureau of the Census and from the National Office of Vital Statistics annual reports, 1942–49, are used to show that:

(*a*) For white births:

(1) Sex ratio of live births decreases both with increasing birth rank and with increasing maternal age.

(2) No consistent association with maternal age is seen when birth rank is fixed, but the downward trend with birth rank remains in each maternal age group.

(3) Sex ratio of stillbirths is high at the extremes of birth rank and maternal age. These two variables cannot be separated for stillbirths with the data available.

(*b*) For non-white births:

(1) When the association between maternal age and birth order is separated, the sex ratio of live births shows no consistent relationship to maternal age, but does show an increase from birth order 1 to birth order 2 and then a decrease with increasing birth rank.

(2) Stillbirths exhibit a U-shaped trend with both birth rank and maternal age, the base of the U being at higher birth ranks and maternal ages than for whites.

Evidence is presented which suggests that the increased sex ratio observed in England and Wales during the last war was not the result of changes either in maternal age at childbirth or in birth rank distribution of the population of births.

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